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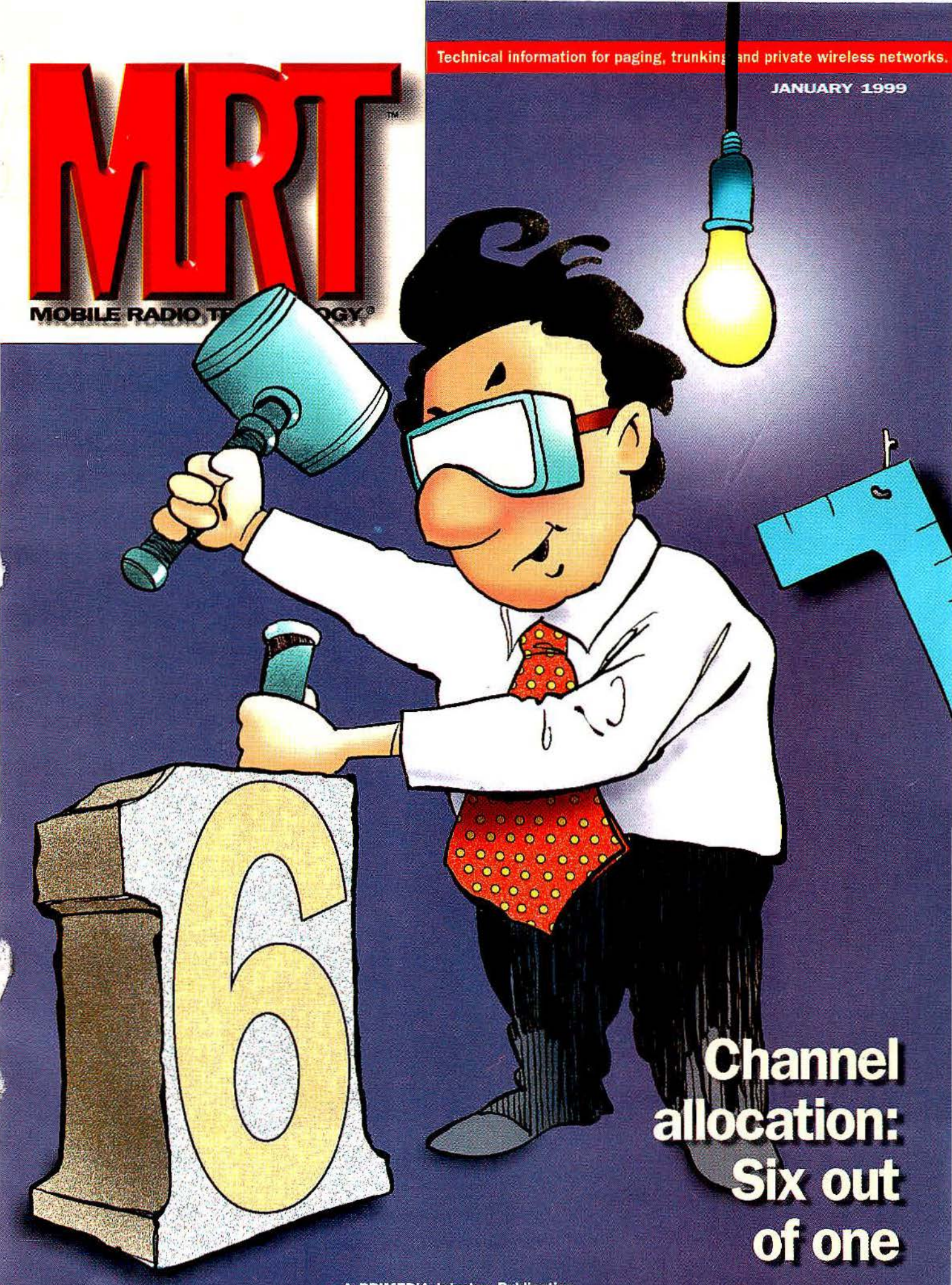

Channel allocation: Six out of one

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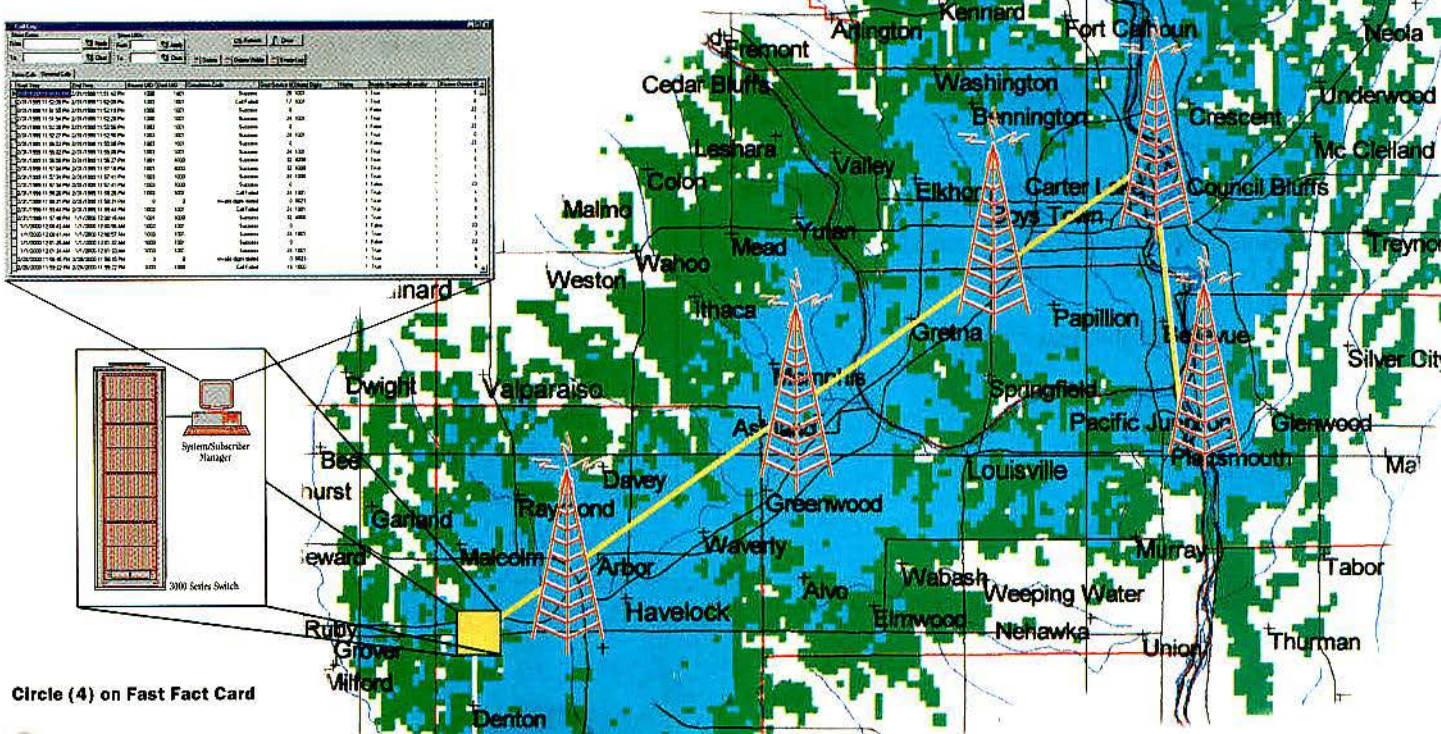

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Technical information for paging, trunking and private wireless networks.

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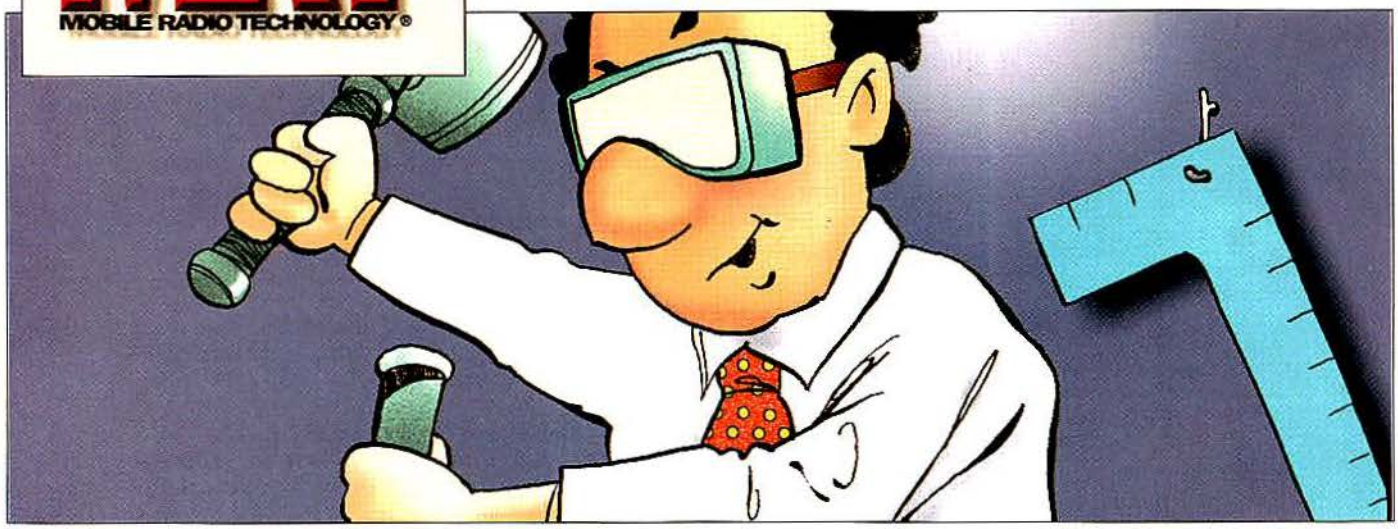
January 1999



On the cover: How can six channels be carved out of one 30kHz bandwidth? The secret is in the centers. *Cover design by Scott Dolash, associate art director.* See story on page 18.

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departments

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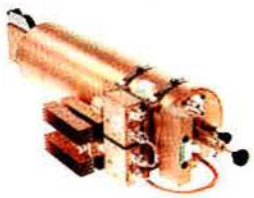

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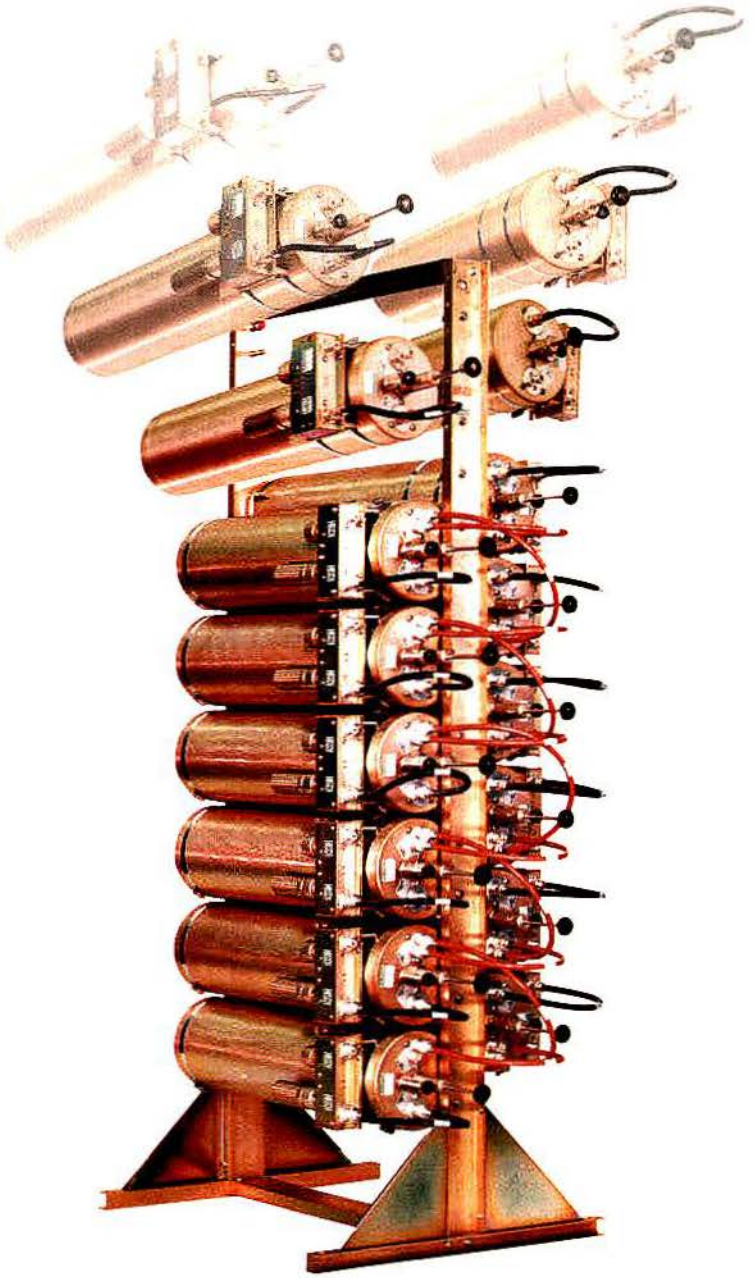

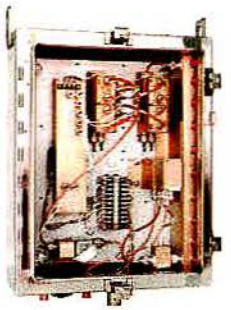

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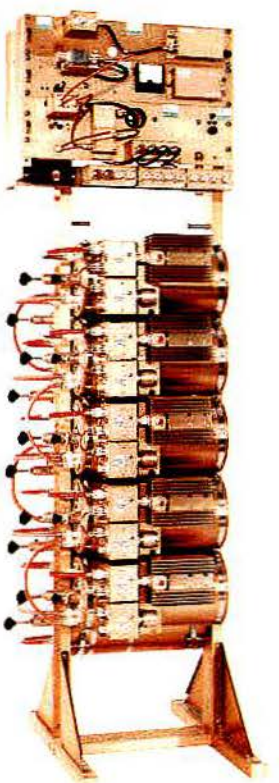

(U.S. PAT. 4,249,147, CAN. PAT. 1,133,598)

For more information on T-Pass multicoupler systems, see our Seminar Subjects booklet, "T-Pass Expandable Multicouplers: Principles and Applications" (Lit. No. C2001F93). Also see T-Pass system brochures (Lit. No. C1011C94, C1021G93, C1031G93, C1041G93, C1051G93). Tech-Aids No. 92002 (Lit. No. D3001D93) and 93002 (Lit. No. D3011F93). Call us for expert assistance in solving your system design problems.

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Money by the briefcase, sites by the thousands and channels split for millions

How long ago are the "good old days?" Ten years? One year? Three months?

Remember when Morgan O'Brien was travelling the country with a "briefcase full of money," as he once described it to a trade show audience, buying up SMR systems for Fleet Call? A lot of system operators sold their SMR businesses. Some of them retained their community repeaters, and some of them retained their antenna sites, or both. Charlie Bonifasi of Phoenix, for example (who, now that I think of it in the context of briefcases, once won a cash prize in a contest at IWCE that was presented as a "briefcase full of money"), retained sites when he sold other parts of his communications business.

Site operation always was a good little business. For people who really understand what they should charge for tower space and who use contracts and other good business practices, it is a highly profitable little business. For yet another group, the tower consolidators, it is a *big* business. Steve Dodge at American Tower Systems, for example, is on the way to amassing 10,000 sites, his company's stated goal, and has in excess of 3,000 already.

Nextel (Fleet Call changed its name to Nextel years ago) itself has a huge portfolio of sites. Some of them it acquired from system operators, and most of them it constructed to support the buildout of its nationwide, cellular-like digital network that primarily uses low-power, low-height sites. Along with other network operators, Nextel is poised to sell its sites to a consolidator and lease back the antenna space. Then, the consolidator could offer space on the sites to other renters.

Meanwhile, some of the former SMR operators are finding new opportunities with wide-area analog trunking and with UHF trunking. Some of these systems are attracting customers who do not need all of the features offered by digital ESMRs such as Nextel, Southern Communications and Chadmoore Wireless and who shy away from the higher bills they might have to pay for something besides "plain vanilla" dispatch.

That's not to say that some customers don't want the extras. Even Geotek attracted enthusiastic, loyal and appreciative customers. It's just that premium, or even mid-range, service isn't for everyone.

It's interesting to see, though, that Nextel probably will get out of the business of owning sites, a business pioneered to some extent by the mobile radio operators, and that the same operators are getting some benefit from dispatch business more or less cast off by the digital system operators.

Steve Virostek, a keynote speaker at last year's IWCE, directs messaging and dispatch studies and consulting at the Strategis Group. He updated his industry report on Nov. 13, 1998, at the AMTEX conference. He pointed out that one-fourth of the cellular/PCS customers are business users.

Prior to the widespread availability of wireless telephone service beginning with cellular in 1983, land mobile radio was used by many who now use cellular or PCS instead. Real estate agents, for example, used to be big customers of land mobile radio. Because their mobile communication normally is with people outside their organization, dispatch service doesn't matter much to them. In the construction industry, though, where mobile communication among managers, supervisors and employees is more important, dispatch service continues to thrive. And flat-rate dispatch service saves them money compared to airtime, per-unit charges on some of the digital networks.

Virostek calls Nextel the "differentiator" in today's wireless marketplace. He found them loading 125,000 subscribers per month, with revenues per subscriber at $70 per month, a lower churn than with cellular/PCS and with long-term customer relationships.

His study found 4.6 million analog and digital SMR subscribers in 1998, compared to 3.1 million in 1997 and 2.2 million in 1996. The proportion of analog SMR, the low-cost alternative, is holding relatively steady at 1.7 million.

One of his report's figures shows analog SMR use at 450MHz grew at a rate of 278% in 1998, followed by 220MHz at 43%. If you're looking for encouraging growth figures, look no further!

What's really huge? The number of non-federal, non-SMR private radio users: 15.8 million. Add the analog SMR users (1.5 million) and the digital SMR users (2.9 million) and you have about 20 million dispatch customers. About 22% of them use cellular/PCS and paging services, too.

Frequency congestion is forcing private radio users to explore other communications options, such as new radio technology, commercial wireless services, partnerships with other radio operators and data dispatch. Channel-splitting technologies such as ComSpace's DCMA and Intek Global's LM may help to overcome some of the frequency congestion—maybe *all* of it, depending on how accurate those companies' own claims turn out to be.

Virostek's report spells out some implications for trunked radio operators.

For the short term:

1. Commercial wireless carriers have abandoned the dispatch market.

2. Analog SMR is shrinking, but non-Nextel SMR operators report a net gain of 9% for 1998.

3. Quick-fix solutions address capacity needs.

4. An opportunity exists to raise service rates from historical averages.

For the long term:

1. Implement capacity-enhancing technologies because new spectrum allocations are uncertain.

2. Maintain a value proposition with respect to competitors.

3. Align with other telecommunication carriers to shore up competitive weaknesses.

How does this compare with your view of the industry? Let us know at *mrt@intertec.com*.

Exit Phythyon, enter Sugrue

The FCC Wireless Telecommunications Bureau welcomes a new chief. Dan Phythyon stepped down from the position on Dec. 1, 1998, to handle special project assignments within the FCC for a while. FCC Chairman William E. Kennard has appointed Thomas J. Sugrue to the bureau post as of Jan. 19, 1999. Sugrue is a partner in the law firm of Halprin, Temple, Goodman and Sugrue. He has had policy-making positions with both the FCC and NTIA in past years.

Don Bishop

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NEXT MONTH - FEBRUARY 1999

FEATURES AND NEWS: towers, remote monitoring, battery maintenance.

PLUS: Robert H. Schwaninger's "In the Public Interest"; Don Bishop's editorial; product focus: base antennas.

AND IN THE MONTHS TO COME: mobile data and telemetry; IM/EMI issues; interoperability; UHF trunking; IWCE preview; 800MHz trunking; solving propagation problems; lightning protection; power systems.

Lightning protection

CORRESPONDENCE: Editorial correspondence should be addressed to P.O. Box 12960, Overland Park, KS 66282-2960. tel. 913-341-1300; fax: 913-967-7250; *mrt@intertec.com*

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calendar

February
8–10—Wireless, sponsored by the Cellular Telecommunications Industry Association, Ernest Morial Convention Center, New Orleans. Contact: 847-940-2155.

March
8–9—Specialized Wireless Communications Management Conference, sponsored by AMTA, San Diego Hilton Beach and Tennis Resort, San Diego. Contact: 202-331-7773.
15–17—29th APCO Western States Regional Conference, sponsored by APCO, San Diego Concourse, San Diego. Contact: 562-940-3362.
28–31—ENTELEC, sponsored by the Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 281-357-8700.

April
28–30—International Wireless Communications Expo, co-sponsored by Mobile Radio Technology, Las Vegas Convention Center, Las Vegas. Contact: 800-288-8606.

May
10–13—Telecommunications Resellers Association Spring Conference and Exposition, San Diego Marriott, San Diego. Contact: 202-835-9898.

June
1–3—Canadian Wireless, sponsored by the Canadian Wireless Telecommunications Association, Vancouver, Canada. Contact: 613-233-4888, ext. 102.
27–July 1—UTC Telecom '99, sponsored by UTC, Nashville, TN. Contact: 202-857-1881.
28–29—AMTA Leadership Conference & Annual Meeting, sponsored by AMTA, ANA Hotel, Washington, DC. Contact: 202-337-7773.

July
14–16—Communications Expo/Show of the Americas, Miami Beach Convention Center, Miami. Contact: Jackie Gonzales, 305-412-9000.
26–28— Telecommunications Resellers Association Summer Carrier Forum, Westin Harbor Castle, Toronto, Ontario, Canada. Contact: 202-835-9898.

August
8-12—International Association of Public-Safety Communications Officials (APCO) National Conference, Minneapolis, MN. Contact: 904-322-2500.

September
23-25—Personal Communications Showcase, sponsored by Personal Communications Industry Association, New Orleans. Contact: 703-739-0300.

October
2–4—Wireless I.T. '99, sponsored by the Cellular Telecommunications Industry Association, Santa Clara, CA. Contact: 202-785-2842.
17–19—TelecomLatina, co-sponsored by *Mobile Radio Technology*, Miami Beach Convention Center, Miami. Contact: 800-288-8606.

November
10–14—Communications Marketing Conference, sponsored by the Communications Marketing Association, Harvey Hotel, Dallas. Contact: Jack Armstrong, 410-628-9300.
15–16—AMTEX, sponsored by the American Mobile Telecommunications Association, Walt Disney World Village, Lake Buena Vista, FL. Contact: 202-331-7773.
15–16—Fourth International Congress on Commercial Trunked Radio, sponsored by the International Mobile Telecommunications Association, Hilton, Walt Disney World Resort, Orlando. Contact: 202-331-7773.
1–4—Telecommunications Resellers Association Fall Conference and Exhibition, sponsored by TRA, Adams Mark Hotel, Dallas. Contact: 202-835-9898.
19–Radio Club of America Communications Symposium, 91st Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 732-842-5070.

editorial index

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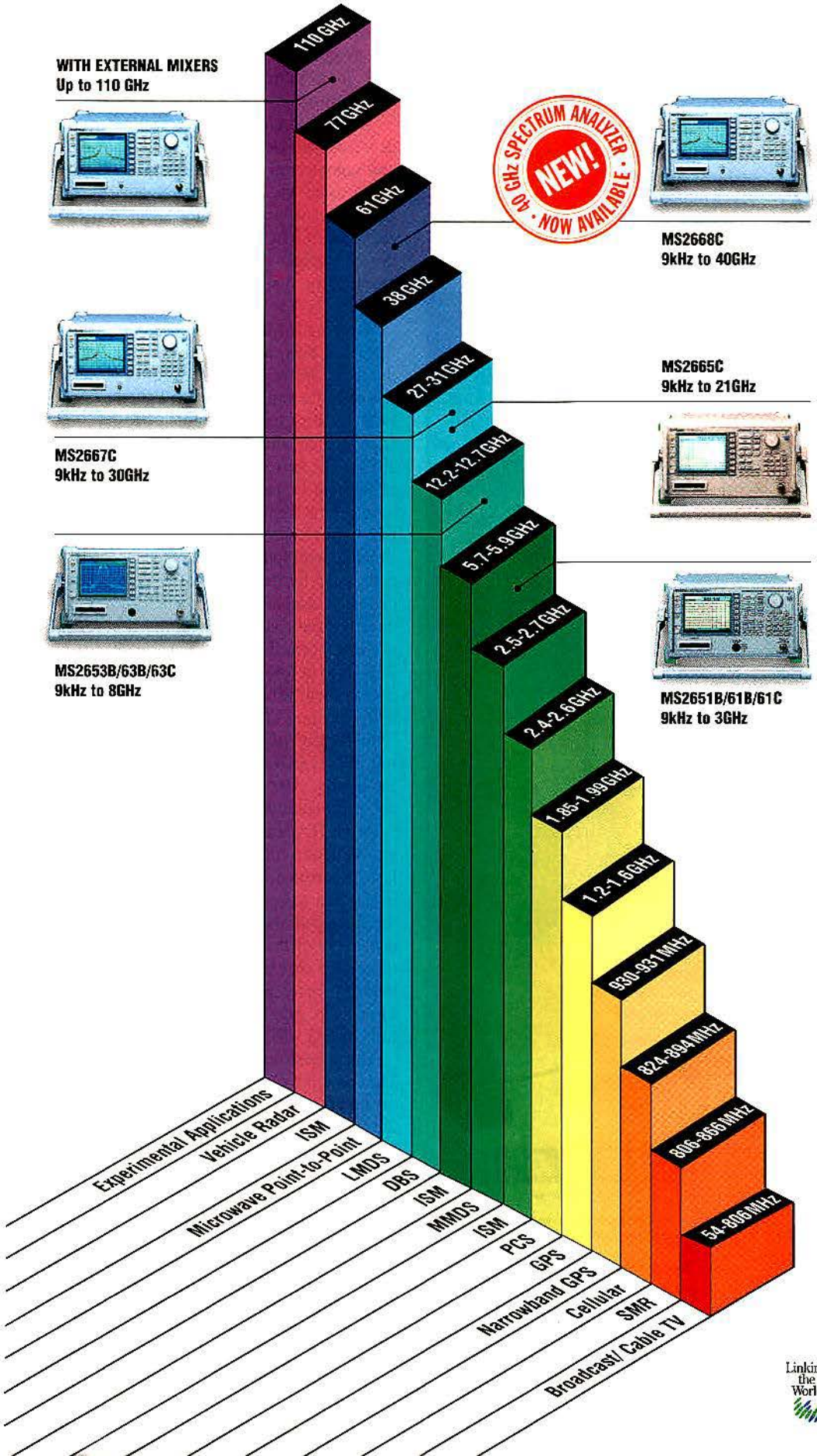

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Circle (15) on Fast Fact Card

A disturbance in the Force

The day that I am writing this, near the end of 1998, happens to be the 97th anniversary of Guglielmo Marconi's first transcontinental broadcast. Some radio historians might assert that it was about a week later that the question was first asked "What are *you* doing on *my* channel?"

Interference is as old as the technology and as current an issue as we have in wireless communications. Technical solutions aside, interference, like history, is as much a result of the absence of decision as it is about the consequence of decision. Failure to investigate existing use when putting in a system is nearly as bad as malicious intent—the result is the same.

The RF environment is getting more dense as new services are "commissioned" and commercial networks expand. Public safety users' groups and consolidated agencies are actively complaining about interference from CMRS, particularly ESMR, and those complaints have not been limited geographically. They stretch from Texas to Oregon.

Not only has the "force" been disturbed, there has been a disturbance in the Force this year. We've felt a presence we haven't felt since the fall of the FOBi knights. (The FCC Field Operations Bureau became the Compliance and Information Bureau in 1994). The first year under the stewardship of Richard D. Lee as chief of the CIB has seen several steps. They include: a cooperative enforcement Memorandum of Understanding with some of the frequency coordinators, led by the Industrial Telecommunications Association (ITA); a crackdown on unauthorized channel use, as noted in *MRT* in November; threats of fines against the 28% or so of tower owners who haven't registered their structures; and, on the broadcast side, the FCC's frigates are chasing the "Jolly Roger" of pirate radio and admonishing the legitimate broadcasters in the Emergency Alert System to clean up their act, procedurally.

At an ITA breakfast in October, Lee acknowledged a column in this magazine from last August that likened the FCC enforcers in the past to "cops permanently parked at the doughnut shop." Not only did he take ownership of that history, he made it clear those days are over. We believe him, and the industry better believe him, too. Lee is a former (*not* ex-) Marine, and he'll take that hill—if HQ will stay out of his way.

Much needs to be accomplished in 1999. The few other coordinators who have signed off on an enforcement MOU with the FCC are limiting their sphere of influence to intramural interference issues within their own services or industries. Interference between ESMR traffic and both LMRS pools—private and public safety—needs to be addressed. *MRT* will stay on top of both the regulatory and the technical solutions to these problems in the coming months. We hope the CIB will be unrestricted by any other FCC agendas so that it can do the same. ■

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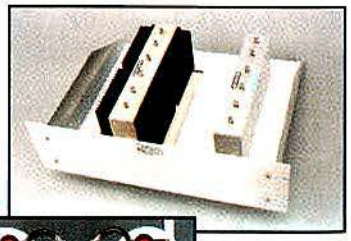

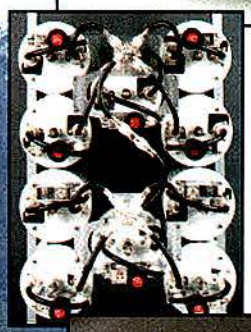

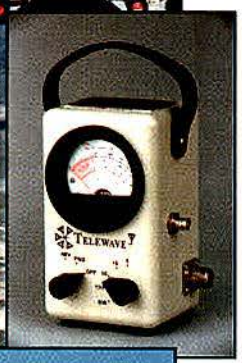

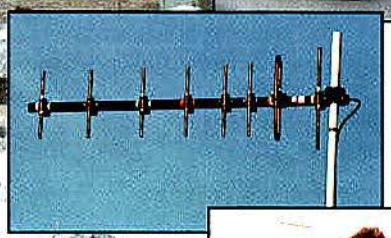

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letters

Technician comments on shortage

I liked the articles on technicians ("Editorial," July; "Letters," September *MRT*) and thought I'd add a comment from an actual technician and not a president or a manager. My answer is yes, there is a shortage of technicians and a drought of good, experienced technicians; but there is no shortage of people claiming to be technicians.

Companies compete for technicians. If there is no shortage of technicians, then why did Optaphone Systems have to move its location to attract technicians? Why all the ads? Why all the banter about finding technicians if there are so many around? Stop kidding yourselves!

Quality technicians are rare. What keeps a quality technician at a job are several things, and the pay and benefits may not even be a part of it (although it helps). And in no real order, let's first consider training.

I do not mean in-house or on-the-job training. I mean actual classroom or vendor training. To make or keep a quality technician means an investment in training. Too many companies pass off training as only college. What company will give daytime off to attend a college class? None! Will a company reimburse for non-college job training? Few and with lots of catches. Vendor training? Sure, but if you are too good at your job, the company can't afford to lose you to school for a week or two. In short, there are many great training courses and seminars out there, but a lot of companies that want a quality tech won't give him or her the money or the time to stay that way and advance.

Next, is by name (not group) recognition—both on job and off. Is there a safety recognition program? Are there certain techs that always seem to be out on a service call while the others hang around the coffee pot? Is the tech that always agrees with the management (even to the point of jumping off the cliff) the only one who ever gets recognition?

Does the company listen? When a technician makes a recommendation on an issue that he/she is the subject matter expert on, does the company listen, or is the technician only shrugged off as "He is only a tech, the manager knows better" or "You're only a tech, if management thought it important they would have thought of it before you."

Teamwork. I don't mean just the word, but the actual meaning and practice of it. If your idea of teamwork means we are with you in spirit or via phone call, I suggest you look up the meaning of the word again.

Getting or making quality technicians and then keeping them are two entirely different issues. Ever wonder why your company either doesn't attract good technicians or keep them after hiring them? It may not be the pay and benefits.

—Dave Kalb
System Technician and Retired Military
Pagenet of Maryland
Catonsville, MD

Greedy license seekers?

"Critical Infrastructure Industries" (Editorial, October *MRT*) as you suggest, is nothing more than a ploy by the greedy to use position and influence to obtain a bigger slice of the pie. From personal observation, I know of one large oil company that holds many unused FCC licenses. While using some of their licenses for normal operation, they hold many others apparently in reserve that are periodically renewed but not supported by an equipment installation. In fairness to that company, I will say my observation occurred nine or 10 years ago.

I would guess this practice is not limited to oil companies.

This practice is responsible for an unrealistic picture of the spectrum as viewed by coordinating agencies. Since little actual investigation is ever done by the FCC or the coordinators, the result is an almost worthless site compatibility profile. Accordingly, some applicants are denied access to apparently crowded sites because of "coordinated" incompatibility with licensed by nonexistent site users.

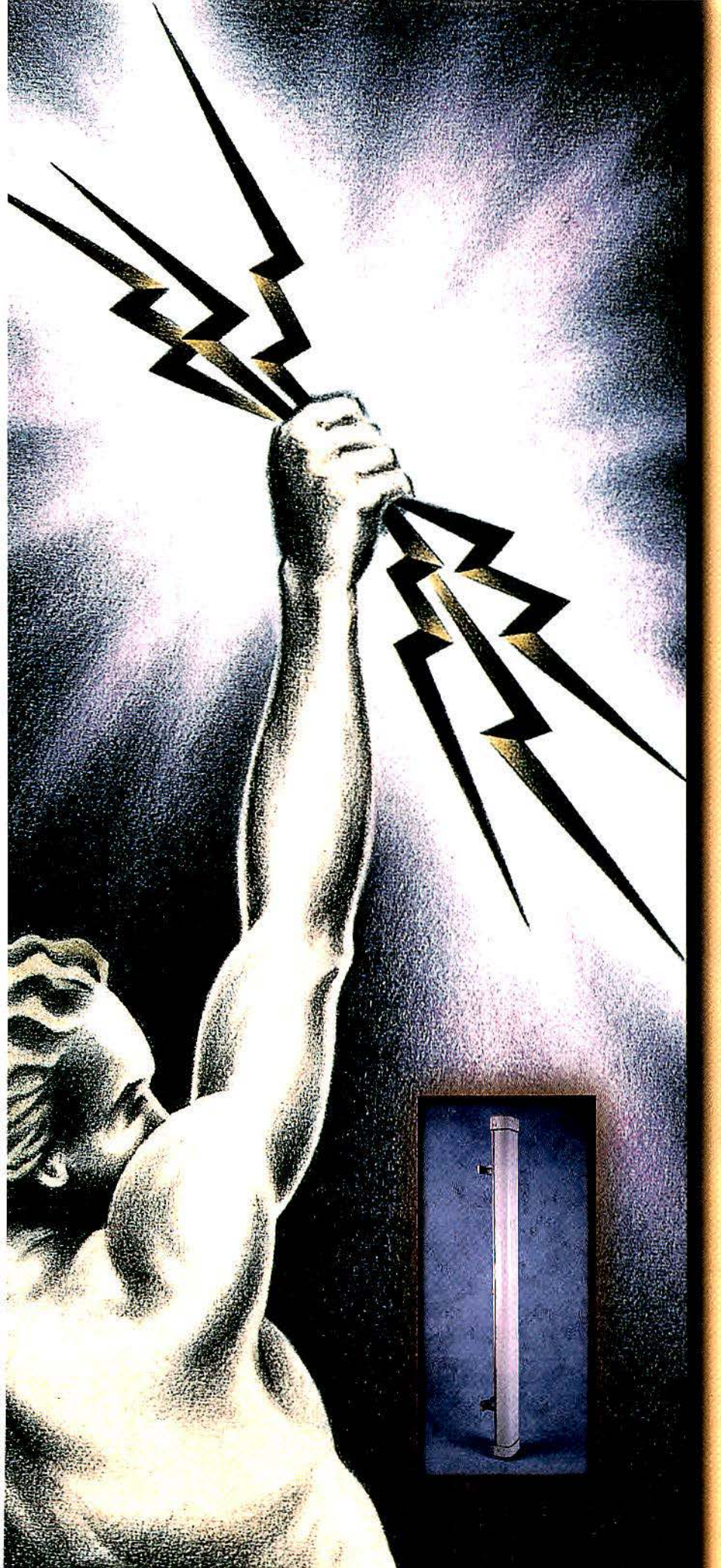
—R.D. Swinney
Andrew
Richardson, TX

Correction

In the December 1998 issue of *Mobile Radio Technology*, RFS Cablewave's address was incorrect in the "Company Addresses" section. The correct address is:

RFS Cablewave
200 Pondview Dr.
Meriden, CT 06450
203-630-3311
Fax: 203-821-8530

Let us know what you think ... Our email address: MRT@intertec.com



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Pickin' fish

By Robert H. Schwaninger Jr.

Every September my wife and I visit the outer banks of North Carolina for a vacation. We spend a week sitting on the sandy shore, watching brown pelicans glide by, listening to the surf and generally forgetting our pressures. I read a bunch of beach books for boys, and my wife collects shells to add to last year's batch that are still in the garage. Every so often she walks by and dusts me. Ah, sweet therapy.

This year, we had passive entertainment in the form of a small group of local commercial fishermen who decided that the spot in front of our beach house was ideal for dragnet fishing. Armed with a small, surf-resistant boat and about 300 yards of net, the fishermen cast a loop off the bank and waited for silly fish to wander in. Then they dragged it out with the help of a pickup truck and loaded their catch into tubs to sell to local fish markets.

The fishermen, led by an old guy named Wilbur (who with a slight costume change could have been a gnome) seemed a fairly happy group. Just three guys making a living on the luck of the nets. Wilbur had smartly added to his crew one guy that stood about 6'5" and had the muscle to pull a hundred pounds of fish onto the pickup bed with ease.

One Thursday, they had a great haul. The number of spot and chub and sea bass flopping in the nets was amazing. Wilbur reckoned it was about 4,000 pounds of fish, and at 23 cents a pound, it would be a good day's catch—if they could get it loaded. People gathered to gawk at the fish, and some of us, for no reason other than neighborliness, helped them "pick fish."

There was a farmer from northeastern Pennsylvania, who was getting a little long in the tooth but still had that strength that came from working a barrel chest and broad back for years, turning the earth. He told me about his family farm. Said things weren't like they used to be, what with all the laws, regulations and agribusiness-related monkey business that was hurting the family farm. I told him I was a lawyer, and after a few minutes' internal debate, he decided it was OK to talk to me some more.

Seems he'd worked the family farm all his life and had made a decent living. But things weren't the way they used to be, and he was afraid that his son wouldn't succeed in carrying on the tradition. Said a lot of the family farms had been sold off in his area, but he just wasn't ready to do that. He liked farming. His son liked farming. It was a family business, and he believed that with hard work, a man should be able to take care of his own and not have to sell everything just to break even.

He looked over at his wife, who had joined us pickin' fish. She was a sturdy woman with an ease of motion that bespoke years of snapping peas and "putting up" jars of applesauce. Together, they moved with great dignity, knowing they were doing what God expected.

After a while, they moved on, figuring they had done their part to help. I stayed on, pickin' fish and shooting the breeze with Wilbur. I asked him about his business. He said he sold fish at about two bits a pound to the fish retailers that then resell it at about $3.50 a pound; then he just laughed.

"If you want about 20 bucks of fish—grab a handful. It ain't nothin'."

I asked him if the business was regulated. Wilbur said, "Well, they got laws about what you can catch, and gettin' a license and all, but that's about it."

"Hey, Wilbur, what would you think about the government setting up a fund that all fishermen would pay into to feed the poor with fish? They might call it the 'Universal Fish Fund.'"

He thought about that, then screwed his bearded face into a scowl. "I don't make that much now, and it seems that charity should begin at home. It just doesn't seem right to take money from me so that other folks who won't do an honest day's work get fish. Besides, I give to the church, and that should be good enough."

"Well, you know, Wilbur, this seacoast is federal, and that means the fish are federal, so the government's letting you make a living using its fish. Doesn't that mean

Illustration by John Hayes

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington. He is a member of the Radio Club of America.

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they're entitled to say what you can do with some of them?"

"Now, *that's* crazy," said Wilbur. "These fish ain't federal. God made 'em, and he lets them run around the ocean, and I'm the one that makes them worth money by hauling them out of the ocean. The government doesn't pay for that, or do that. Besides, they get my income taxes. Whatta they want *more* for?"

"Okay," I said. "I get your point. But how about if the government decided to raise money by auctioning off fishing rights? They might create a program for you to bid on the right to fish these banks. If you won the bid, you would be able to haul out fish between, say, here and Nag's Head, without competition from other fishermen. What would you think of that?"

"I couldn't do it," he declared with a laugh. "The truck takes about $100 a month to run, and nets need upkeep and the boat and motor and all—it takes money! Now, on a regular day, I get about $500 worth of fish, but the profits gotta be divvied up amongst us all. I get about a hundred a day. That's enough to take care of my family, but it doesn't leave much for biddin' in a government-style auction to fish."

"But you'd get the right to fish the whole bank," I protested. "You could expand your operation and get a bunch of crews working down here. You might get rich."

"That ain't gonna happen," he said flatly. "Even if I *could* afford to buy the rights, I couldn't afford the trucks and the boats and pay to pull it off. Hell, what am I supposed to do, borrow the money from a bank? They don't lend money to li'l' ol' fishermen like us. Besides, I still owe on the house."

"I understand," I said, and we dropped it. I went back to pickin' fish and squatted down to load several more handfuls of spot into a tub to be dumped into the back of the pickup. I worked with Wilbur and his crew until it was getting close to sunset. The smell of the dead fish clung to my hands where the fins had made little bloody pinholes in my palms. Together, we finished putting the two-bits-a-pound bounty in the trucks, and Wilbur thanked me, chuckling about wanting to get home to tell them that some lawyer helped them make the load.

I waved to my new fishing buddies and walked slowly back to our beach house. My wife immediately directed me to a hot shower to get the fish smell off. Afterward, she looked at my hands and said I should put some lotion on them, but I declined with a mumble about honest work. Truth is, my hands ached from helping Wilbur, but pickin' fish felt good, and I didn't even have to fill out a form. ■

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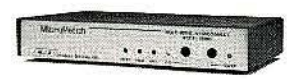

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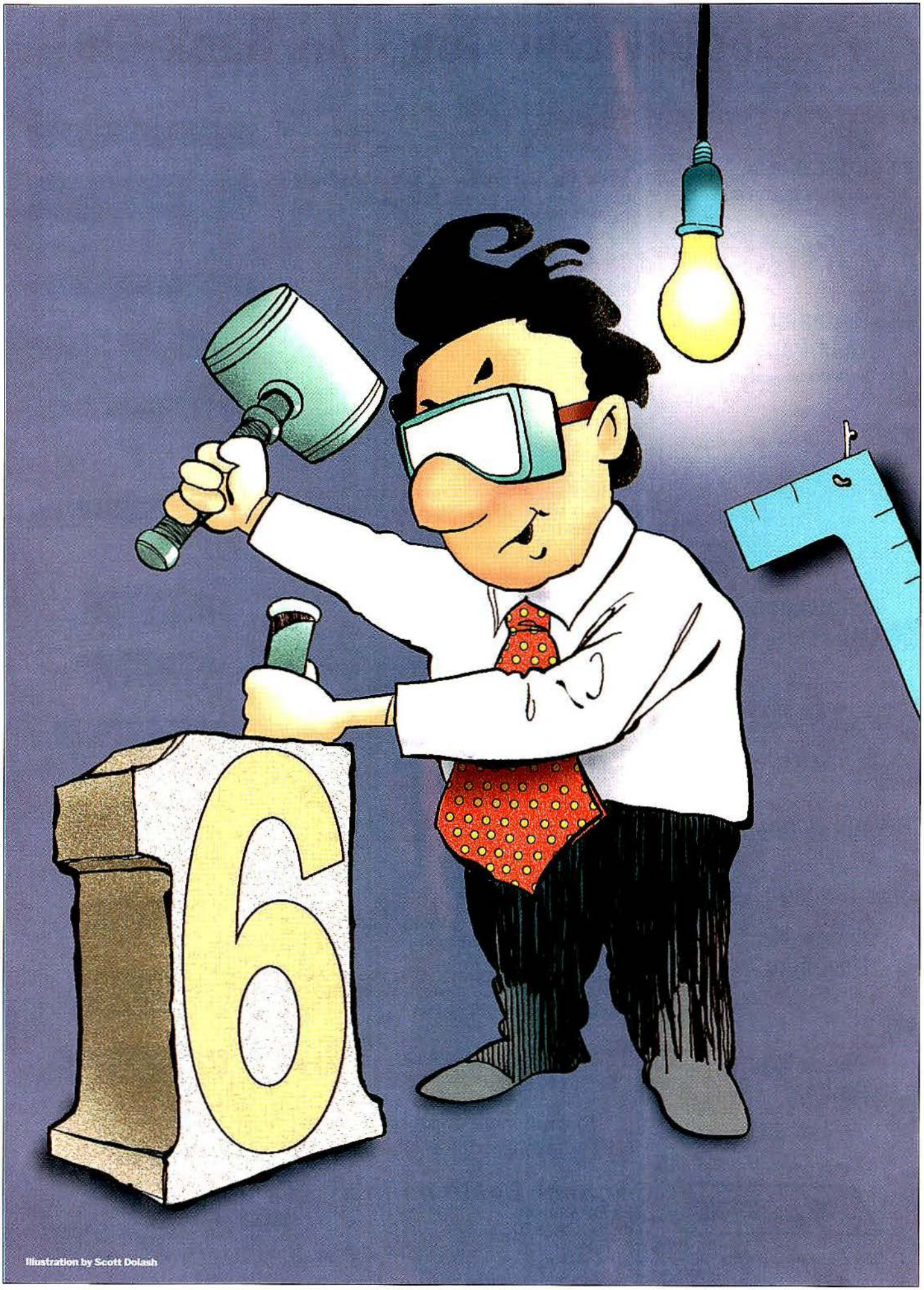

Illustration by Scott Dolash

Six into one *will* go

Technology already proven for 220MHz applications now focuses on the need to increase capacity and efficiency for VHF highband.

By Michael R.J. Bayly, C.Eng., M.I.E.E.

The availability of linear modulation technology, already proven in 220MHz applications, and the requirements of the FCC refarming order (92-235), finalized in 1997, have converged to create new opportunities for VHF highband communications as well.

Technology in-waiting

Although "linear modulation" (LM) has been in use for decades, in its contemporary context it refers to LM implemented with the merging of four additional technologies: reference vector equalization, Cartesian loop transmitter, feed-forward signal regeneration and digital signal processing. In this incarnation, very narrowband linear modulation (VNLM) was first demonstrated in 1992 and was type-accepted by the FCC in 1994, at which time it began to be applied to several 220MHz systems. The 220MHz–222MHz auction in 1998 has given impetus to extending use of that band beyond single-site applications.

Refarming revisited

One of the goals of refarming was to get the best spectrum efficiency. There is limited *existing* spectrum, *limited* new spectrum and congestion in the bands in current use. There are also limitations to many of the current wireless technologies.

One solution is to increase the current spectrum capacity. Various ways are being promulgated to do that. The FCC could mandate a reduction in channel size. In a way, that is one effect of the type-acceptance process because increases in interference will actually drive system managers to reduce channel size. Because type-acceptance is questionable as a policy tool, some industry organizations are pushing for a more specific mandate that would encourage a transfer into more spectrum-efficient technologies.

Another solution is to increase the channel capacity by various other ways, either by using that channel for less time or by substituting data, a more efficient means of communicating information, for voice when feasible. A similar solution is to provide higher-speed data on the channels, and LM technology already provides 128QAM (quadrature amplitude modulation) trellis coding, yielding as much as 16.8kbps on 5kHz channels.

Another approach is to provide more functionality by trunking. Many systems are now moving toward trunking because of the increased efficiency that technology brings.

The refarming effort enables more users to simultaneously access the available spectrum by using bandwidth more efficiently. That's the whole objective, and the FCC has mandated more spectrum-efficient technologies through its type-acceptance process.

Needs assessment

What does this really mean to users? Users are saying, "We need *more* channels now, not in 10 years' time." More new users want access to spectrum, and existing users want more channels because they want to enhance the capabilities of their wireless systems. For example, public safety is demanding bandwidth to transmit large files containing photographs, fingerprints and video.

Users want better *performance*. Whenever there has been a reduction in channel bandwidth, there has been an attendant reduction in voice quality. The move toward purely digital systems also degrades overall voice quality.

Users want voice and data available in their products *now*. Most users do not want to undertake another change-out of equipment in seven years (2005) when the 6.25kHz-spacing requirements are in place.

Users are still looking for *direction*. We often read in the trade press that there still is not a "good direction" that users can go to for refarming because some of the proposed solutions have technical or practical drawbacks.

Applying LM technology

LM is a practical solution to the strains driving refarming and the needs of users because it can exist *within* the crowded spectrum. LM does not need new, cleared spectrum to operate. It uses just 5kHz channel bandwidth, and it is a frequency-division multiple-access (FDMA) system, not TDMA or CDMA, alowing flexibility when planning a wide-area, multichannel or multisite system.

Read the fine print

The capacity of a 30kHz FM channel can now be increased by up to six times. The rules are already in place.

A lot of people who have only glanced at the FCC rules say "No, no. At VHF highband, the channel spacing is *7.5kHz*." Re-read the rules more carefully. They say you can actually do anything you like, including 5kHz, which is important because it enables this technology. Users are asking for more channels now, and there have been ongoing demonstrations for the frequency coordinators of how LM technology can support management of crowded spectrum.

Run the numbers

Differences exist between the technical performance of the prevailing FM technologies and LM, as shown in Table 1 below. The modulation type is *linear*, with a non-constant envelope system (as are most of the digital systems). LM uses just

Table 1. Comparison of linear modulation and FM (FDMA).

	MODULATION TYPE	CHANNEL SPACING	CO-CHANNEL PROTECTION	VOICE INTELLIGIBILITY	USEFUL DATA RATE	MEAN B.E.R.	MEAN POWER
LM	LINEAR	5kHz	10dB	90%	14.4kbps	2.5×10^{-3}	8W
FM	CONSTANT ENVELOPE	12.5kHz	12dB	77%	1.2kbps	7.5×10^{-3}	25W

Data based on trials conducted by the Department of Trade and Industry, United Kingdom.

Bayly is director of Linear Modulation market development for Intek Global/Midland USA, Kansas City, MO.

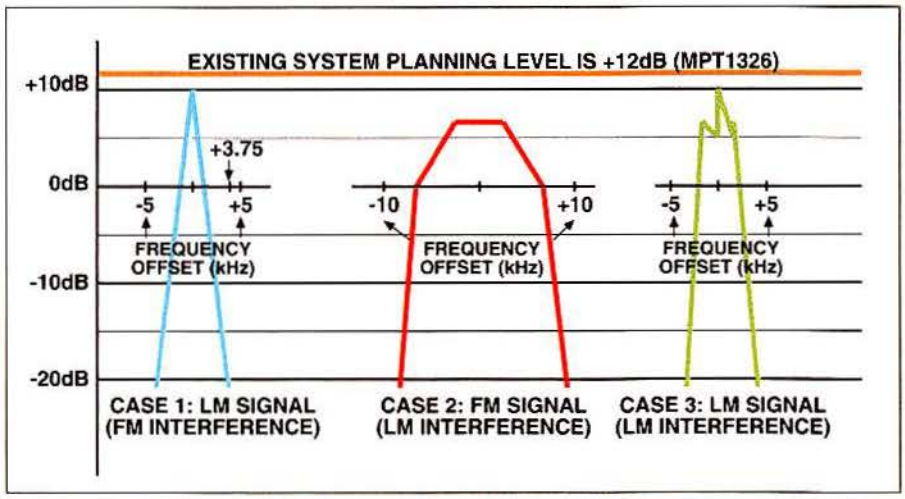

Figure 1. Co-channel protection ratios for linear modulation and frequency modulation..

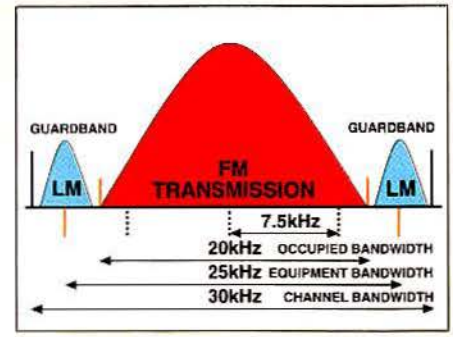

Figure 2. VHF highband 30kHz channel allocations.

5kHz of bandwidth and has a co-channel protection ratio for LM:LM that is 2dB better than a 12.5kHz FM system. At range edge, when you're down at 12dB SINAD and you're comparing FM with LM, trials using random-word test procedures have established that voice intelligibility at low signal levels with LM remains highly intelligible and readable, even with a weak carrier.

How do we define a "useful" data rate? It is the rate at which information can actually be sent and *recovered*. The recoverability of data at 12.5kHz FM is considerably less than at 25kHz. LM provides a mean bit-error rate (BER) advantage because of how the system works and recovers the signal. (Incidentally, 12.5kHz spacing is actually *old* technology. The United Kingdom adopted it 30 years ago. It is not only old, but in many respects it has become "time-expired.")

The more RF a site generates, the greater the potential for interference. But that spiral can be broken. For FM, mean power, average power and peak power are all the same. (In fact, whether you're transmitting information or not, you're still transmitting peak power.) LM power output is not constant. The mean power is considerably less ($^1/_3$) than FM. Consequently, the amount of current that is drawn, and the amount of potential interference that is transmitted, is considerably less. The overall effect is a lessening of the level of RF that can cause interference.

Six out of one

Co-channel interference ratios are the key to practical refarming. Figure 1 above illustrates that you can put LM into the FM environment with minimal interference. This is a 12.5kHz example, not a 30kHz example, that shows that with the LM signal just 3.75kHz away, it can cope with with an

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interfering FM signal 32dB higher, with the same co-channel interference ratio.

Looking at a VHF FM highband 30kHz bandwidth (Figure 2 on page 20), what you're actually authorized to occupy is 20kHz; that is, the emission designator for that bandwidth is only 20kHz, and that is where the FM signal sits. The *equipment* bandwidth is 25kHz, but the *occupied* bandwidth is only 20kHz. This leaves space, the guard bands, at the upper and lower sidebands. Now, the 20kHz bandwidth will accommodate two LM channels in the adjacent guard bands with minimal interference into the FM, or for the FM into the LM. (We have spectrum analyzer documentation of this configuration. Combining equipment is not yet available to do this at the same site, but it is certainly achievable now within a mile or two radius.) Figure 2 also shows the 7.5kHz channel centers that have been designated, but not *mandated*. There is an advantage in *not* using those channel centers because it improves the interference ratios.

So how do we do refarming? At the first stage (Figure 3, above, top line), you can easily put three 5kHz channels on the 7.5kHz channel centers, but that leaves considerable wasted space. The second stage (Figure 3, middle line) we jokingly refer to as the "attorney's view" that says "You actually have to use 25kHz *equipment*, therefore you can do whatever you want to, over 25kHz." That would allow for five channels on 5kHz channel centers, but there is still wasted upper and lower space.

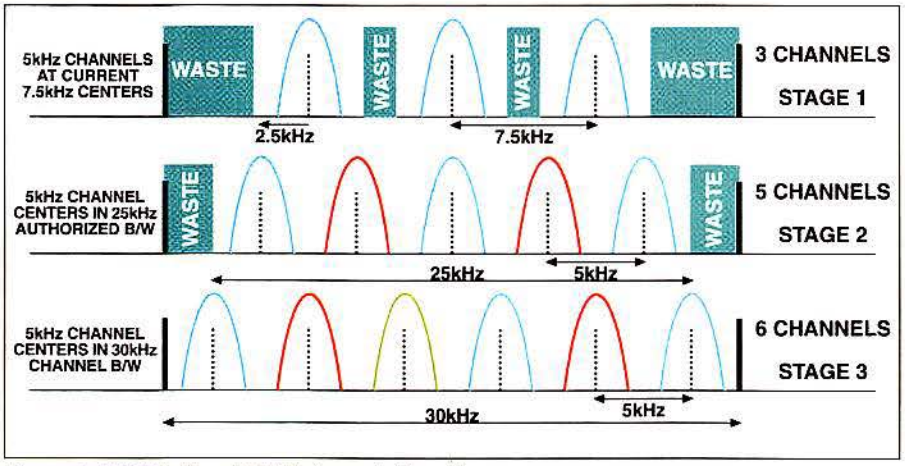

Figure 3. VHF highband 5kHz channel allocations.

Six channels can be located in that same 30kHz as the rules are written. (Figure 3, lower line.)

Intek Global has already gotten a license issued for the stage-one configuration. A four-channel application is undergoing review at the FCC. A six-channel application is being processed, with the Industrial Telecommunications Association (ITA) as frequency coordinator. We're testing the situation, orders are already in hand for the first six-channel systems.

Summary

LM accomplishes the goals of users, regulators, frequency coordinators and manufacturers. VHF highband LM equipment is now type-accepted, and the first license has been issued. You do have a choice; six into one will go. ■

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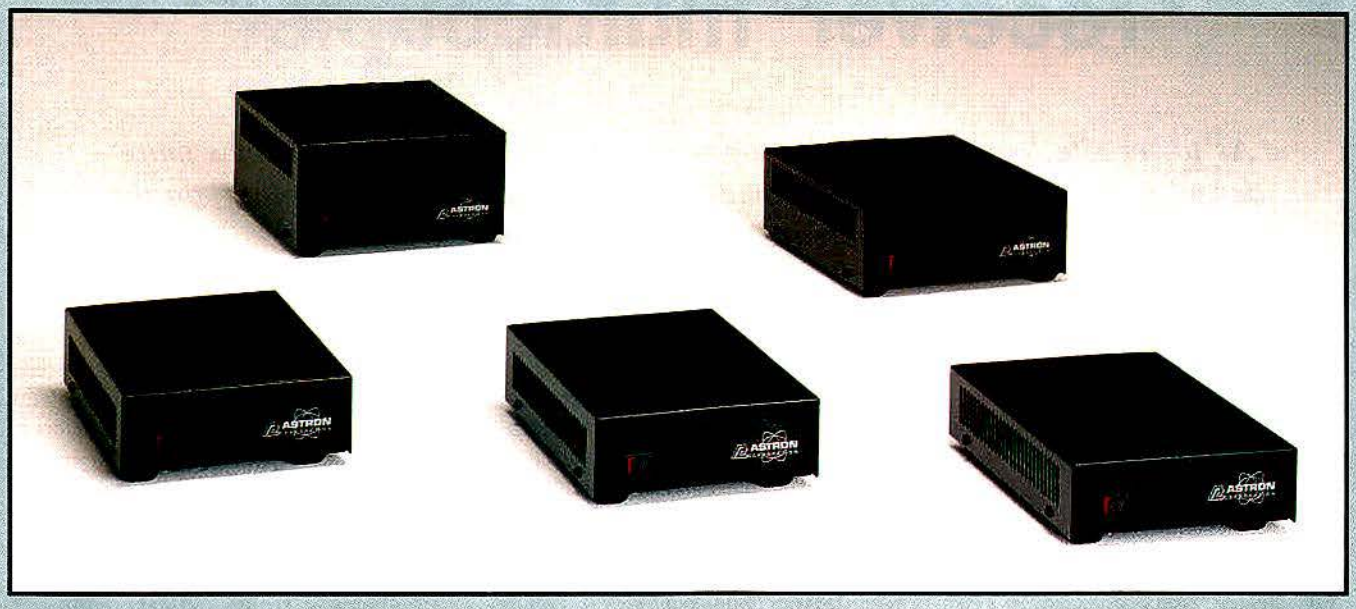

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Radio 101: Anatomy of a receiver multicoupler

As tower site locations become more scarce and occupancy becomes more dense, receiver multicouplers provide a way to reduce 'outside plant' on the tower and to increase coverage from the existing site.

By the *MRT* staff

Tower space is as precious a commodity now as it has ever been, creating the dual problems of placing antennas and increased risk of interference from overcrowding. Thus, the established options of transmitter antenna combining and receiver antenna multicoupling are as essential to land mobile communications today as ever. One solution to the problem of fewer available sites is to make do with what you have by optimizing the number of antennas used. A combiner and multicoupler system can also reduce the level of intermodulation interference between some transmitters or receivers at a radio site, which is a common problem at towers with separate antennas for each repeater system. Isolation also needs to be considered. Multicoupler configurations can be transmitter multicouplers, receiver multicouplers or transmitter/receiver multicouplers, but this discussion focuses on the basic receiver multicoupler.

There are several benefits from a well-designed multicoupler system. The proper preselector can provide optimum filtering of signals. A lower noise figure can be provided for all receivers in the system. Amplification provides wide dynamic range. Proper site analysis and design will also allow better deployment of both receive and transmit antennas. If properly done, coupling of two or more receivers into one antenna should yield equivalent or superior performance compared to having a dedicated antenna for each receiver.

Various manufacturers make multicouplers for virtually every land mobile frequency, from 30MHz through 960MHz. Depending on the application, multicoupling can be as simple as two channels from one antenna to as many as 192. The most common systems are offered by manufacturers with a geometrically increasing number of available

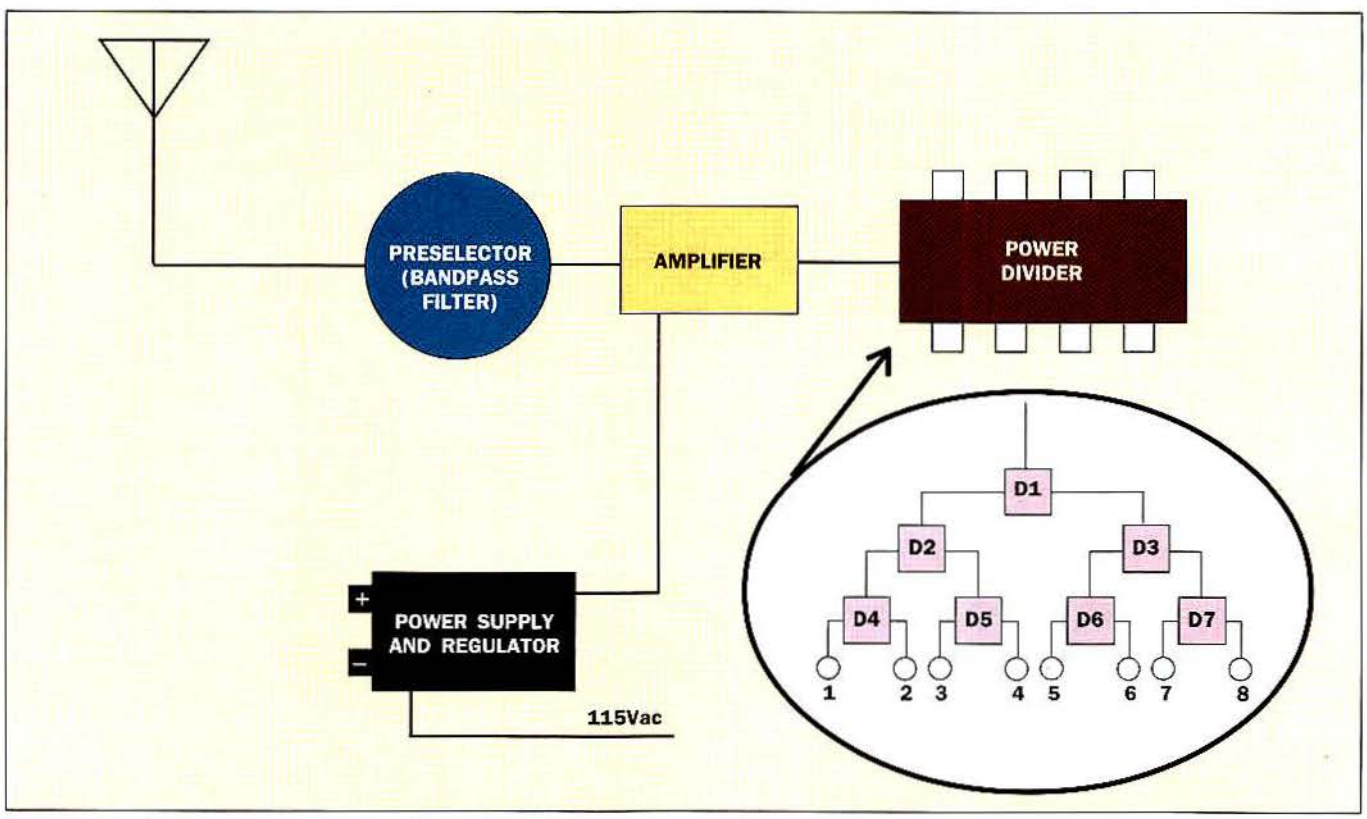

Figure 1. An eight-channel multicoupler. The receive antenna feeds a bandpass or pass-reject preselector that in turn feeds the amplifier, which drives an eight-port (receiver feed ports) power divider, with seven hybrid elements. (The power divider is also informally known as a 'splitter.') A dc power supply provides regulated and filtered power to the amplifier.

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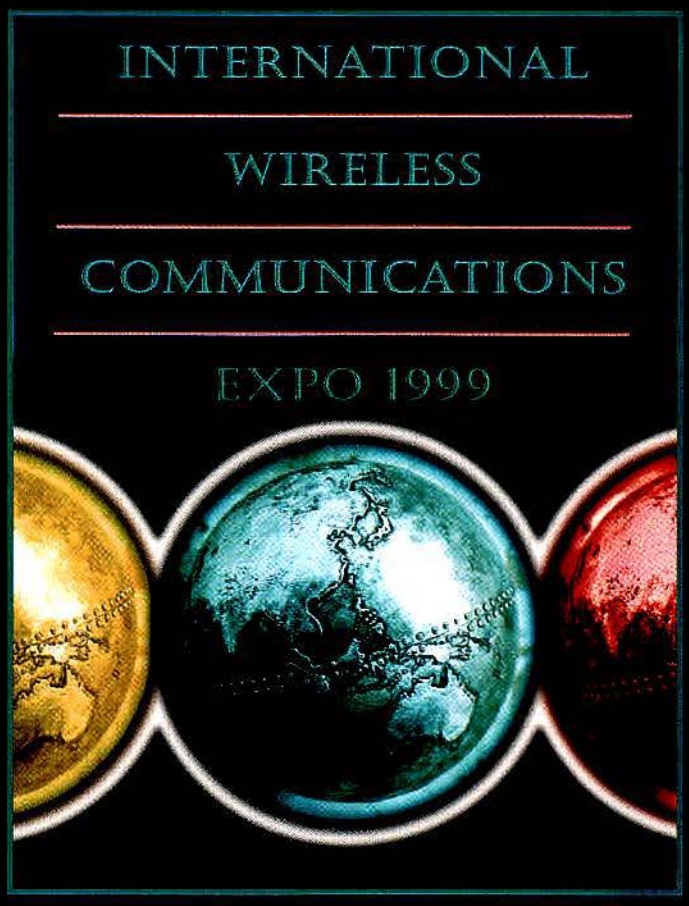

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receiver outputs: two, four, eight, 16, 32 and 64. Custom sizes, like 12 ports, are also available. Some systems are expandable, allowing further branching into more receivers; others are not. Receiver multicoupler systems can be rackmounted in the equipment shelter, or, in some cases, there is an advantage to using a towertop system directly adjacent to the antenna. In both cases, the essential components of the system are the same: an antenna connected by a transmission line to the input of a preselector, the output of which is fed into a high-performance amplifier with an attendant power source. The output from the amplifier is fed into a series of one or more signal power dividers terminating in two or more receiver feed ports and, ultimately, the receivers. The intermediate equipment is usually housed in a single chassis. The two terminals of the system, the antenna and the receiver, deserve attention first.

Antennas

Although the antenna is supported by, and is technically not part of, the multicoupler system, it requires consideration first. Because a common receive antenna is being used, it should be in the best location available. Antennas that feed multicouplers require sufficient bandwidth for the range of frequencies involved. If the antenna is not appropriate to the application, everything in line behind it is wasted technology. Receive antennas should be removed far enough from all transmit antennas to prevent amplifier overload or the coupling of wideband transmitter noise into the multicoupler passband range. A minimum of 30dB, and a preferable 60dB, of isolation is recommended between the receive antenna and any transmit antenna.

Receivers

No matter how well a multicoupler system is designed, it cannot overcome deficiencies in the receiver design. Dense sites, in particular, need top-of-the-line, fixed-installation receivers that are shielded properly and have appropriate cabling, filtering and bypassing.

Receiver sensitivity is the receiver's ability to produce a specified demodulated signal output compared to a reference modulated signal of *x*-strength. For FM narrowband systems, the 12dB SINAD measurement method is a standard, relating recovered modulation referenced to noise *and* distortion.

Beyond the ambient RF noise at a site, all of the elements of the receiving system—antenna, line, connectors and receiver circuits—generate some thermal agitation noise as well. *Noise figure* is the capability of a receiving system to detect a signal against a reference level of noise. The actual system is compared to a theoretical, noiseless receiver. Noise figure is a combination of two ratios, the signal-to-noise power ratio of the receiving system and the noise power ratio of the theoretical system, given in decibels. The lower the noise figure, the better the receiver.

The expression *third-order intercept point (TOI)* pertains to the first stage in a receiving system (as does noise figure). TOI measurements indicate the receiver's ability to a accept a range of signal power levels without generating intermod products within the system itself. The TOI defines a level where two signals, *A* and *B*, applied simultaneously to the receiver's input, will push the first-stage amplifier into nonlinear operation and create a measured third-order $(2A-B)$ intermod product. TOI is expressed in decibels, referenced to 1mW of signal power, or *dBm*. The higher the rating, the better the dynamic range of the amplifier. A typical performance specification for $(2A-B)$ is 80dB below the input levels of frequencies *A* and *B*.

The noise environment should be assessed before committing to a multicoupler design. *Site noise* is the difference in 12dB SINAD sensitivity of the receiver as measured with a 50Ω dummy load and

then with the antenna feed line in place. *Noise figure* is the ratio in decibels of the noise output divided by the noise input. A typical value for a receiver multicoupler for VHF highband is 6.5dB. Several manufacturers have developed multicouplers that use tower-mounted preselectors and amplifiers to overcome the loss in effective noise figure caused by long transmission lines.

Voltage standing-wave ratio (VSWR) is the impedance match of the input and output of the multicoupler to 50Ω. A typical VSWR for a receiver multicoupler is 1.5 for both input and output.

Preselectors

Transmitter combiners and receiver multicouplers are basically filter configurations, and the preselector is basically a bandpass filter that prevents overloading of the receiver system by strong signals. The preselector shapes the pass and reject band responses to signals reaching the input of the amplifier stages of the receiving system. The type of preselector used, bandpass or pass-reject, depends on the band of operation desired, the site requirements and the amount of antenna isolation that can be provided. Preselector passbands from as narrow as 0.5MHz to more than 20MHz may be used, depending on specific site and equipment requirements.

Where sufficient antenna isolation is available, a bandpass preselector can provide a 5MHz passband and 3dB to 4dB per MHz of added rejection above and below the desired receiving frequency range. But at many 450MHz repeater sites, the highest of the paired transmit frequencies would be close to the lowest receiver frequencies. This requires special preselector designs and characteristics.

The preselector should pass the target range of frequencies of the system's receivers with a flat response and low insertion loss. Simultaneous rejection of all other frequencies is desirable. Preselectors can be single or dual-cavity resonator combinations or multistage inductive, aperture-coupled or combination filters. Preselectors should be frequency-stable over a range of environmental conditions, including temperature, humidity and vibration.

Preselector bandwidth is measured at the frequencies where the attenuation is 3dB. A typical preselector bandwidth for VHF highband is 1MHz. A typical value for 450MHz is 6MHz.

The only component of a multicoupler that really can be adjusted after installation is the bandpass network. Contemporary wisdom is to test the filter by directing a signal into a receiver through the receiver multicoupler. If the receiver operates with reasonable sensitivity, don't monkey with the bandpass filter.

Amplifiers

The RF amplifier feeds a series of power dividers, and it compensates for loss in that division process. Amplifier gain can range from 10dB to 60dB. In practice, some amplifiers provide about 22dB gain in the 150MHz–170MHz range and about 17dB gain in the 450MHz–512MHz range. Standard land mobile system amplifiers for the 30MHz–50MHz, 72MHz–76MHz, 132MHz–174MHz, 406MHz–512MHz and 800MHz–960MHz ranges have gains from 15dB to 26dB and noise figures from 1.8dB to 3.5dB. Noise figures of 3.0dB to 5.0dB are also typical, depending on frequency.

TOI ratings for amplifiers can be as much as +35dBm. Most amplifiers are optimized for the best noise figure and linearity at a fixed gain. Coaxial T-pads can be used to attenuate excess gain depending on the number of power division splits coming off the amplifier.

Power supplies

The amplifier should be powered by a regulated and filtered power supply,

whether inverter or converter. Power supply output is generally 20Vdc@0.6A for U.S. applications, whether the power source is ac or dc.

Power dividers

A broadband *power divider* divides the signal received from the antenna into discrete, matched-impedance feeds while isolating the output ports from each other. Each output port feeds a receiver (or a 50Ω load, if the output port is not being used.) To feed *N* receivers from a common antenna, the input is divided *N* ways. Impedances must be matched at all ports. Isolation needs to be maintained between the receivers to avoid any intermod interference generated in any one receiver from reaching the others receiver. Signal power dividers, or "splitters," based on hybrid coupler principles, provide both the coupling and the isolation simultaneously. A signal at receiver frequency *A* will be attenuated by a certain number of decibels at the port for receiver frequency *B*. A typical specification is 25dB or more of isolation between all receivers fed by the common multicoupler.

Any unused ports can be terminated in a resistive load, such as a low-power (1/4W) 50Ω termination. This maintains impedance match and balance throughout the divider system and prevents signal leakage from the open port. Terminations are usually BNC or Type N.

TABLE 1. Insertion loss created by power division.

OUTPUTS	SPLITS	INSERTION LOSS
2	1	3.2dB max
4	2	6.4dB max
8	3	9.6dB max
16	4	12.9dB max
32	5	16.1dB max
64	6	19.5dB max

Each two-way split creates 3.1dB to 3.3dB of loss, plus small conducted losses of 0.1dB to 0.2dB, as shown in Table 1 above.

Various combinations of splitters can be used depending on the number of receivers to be fed and the site requirements in terms of cabling runs and rack position. Multiple cable runs and cabling costs should be minimized, as this also reduces undesirable cable signal and noise coupling. Again, the number of outputs from the power divider, as well as the frequency range, affects the amount of system gain realized.

Towertop vs. rackmount

The point of towertop installation is to improve receiver sensitivity. Contemporary towertop amplifiers have a better noise figure, a higher TOI point and protection from lightning damage than they did just a few years ago. A towertop multicoupler can improve performance from as much as 4dB to 9dB in measured effective receiver sensitivity, and it can also improve range, compared to a comparable rack-mounted, shelter-housed system, particularly for multiple land mobile fixed receivers at remote communications sites. The improvement in signal-to-noise (S/N) ratio at the receiver input compensates for S/N reduced by transmission line loss, which would otherwise mean that the SINAD at the antenna would be greater than what actually arrives at the receiver. Improved sensitivity can moderately improve the coverage area and reception from marginal locations inside that coverage area. The bad news is that the noise level of adjacent carriers increases as well. That can increase unwanted receiver intermodulation products. A towertop amplifier's gain and low-noise figure may improve sensitivity, but the amplifier cannot overcome a 10dB–12dB power difference between a base station transmitter and a portable transmitter. If the antenna population at the site is particularly dense, and there is a high site noise level at the receiver frequency, a towertop amplifier may not be a good idea. Because any received noise improves along with the intended signal, weak signals from the edge of the coverage area, which have a low carrier-to-noise ratio (C/N), are not improved by amplifier gain.

If the site noise is not significant, then a towertop system may improve system sensitivity. If the noise difference is a few decibels, then there will be less improvement. If the noise difference is several decibels, then you may be tying money to the tower.

Bear in mind that towertop systems are a significant investment placed in a location particularly "attractive" to lightning strikes and transients. Adequate lightning protection for the components is absolutely essential.

Conclusion

There are a few caveats about multicoupling. Receiving antenna cable should be routed separately and removed as far as possible from transmit feedlines. They can be run up opposite tower legs and use different shelter exits. As mentioned previously, any unused ports in the power divider should be capped with a resistive, 50Ω termination. Finally, reliance on one antenna requires an emergency backup plan. If the multicoupler fails, or its antenna or line degrades or fails, all the receivers may be degraded or put out of service. Have a redundant system available for a quick swap-out.

Properly executed, receiver multicoupling can rectify at a site that includes numerous duplex stations or is burdened with unacceptable interference, or both. Adequate isolation must be available between the common receiving antenna and various transmitting antennas to secure the rejection of both transmitter carrier and noise. Such isolation is often obtained with collinear spacing. Consult with the manufacturer to ascertain the appropriate spacing requirements. ■

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Trunking the EDACS way

Part 1— A discussion of the basic configurations, terminology and operations associated with Enhanced Digital Access Communications System technology.

By Jeff Ashley

Ericsson GE has maintained its standing in the trunked radio arena for many years with a system they called EDACS (Enhanced Digital Access Communications System). This marriage of RF and digital technology produced a system that has grown in popularity. Installations can now be found around the globe for use in both the private and public sectors. This article is the first of a two-part series that will discuss basic EDACS configurations, terminology and operations.

Basic EDACS — trunked failsoft

Depending on system requirements, EDACS system configurations can be quite different. The simplest is referred to as "basic EDACS," where the system operates in the *trunked failsoft* mode. This means the trunking operations are controlled by individual processing units, one corresponding to each channel in the system (See Figure 1 below.) These units are called GE trunking cards (GETCs) and form an architecture of distributed processing where when one GETC fails, the rest continue handling the trunking operations for the remaining functional channels. These GETCs are connected through a 19.2kbps serial data bus called the back-up serial link (BSL). The cards are capable of communicating with one another rapidly over this link so that each GETC is kept up-to-date on what the others are doing.

Full-featured trunking

In contrast to the distributed processing of the trunked failsoft mode, an EDACS system can also be configured to dedicate the normal trunking processes to a single, centralized computer called a *site controller*. This site controller, in turn, is connected to another computer called a *system manager*. The system manager is the interface between operators and the system and is capable of (among other things) generating reports that help evaluate the operational performance of the trunked system. Its reports include database information for the various units, groups and sites, system activity, site and channel usage statistics and alarms. (See Figure 2 on page 30.).

This EDACS configuration is referred to as *full-featured trunking*. There are several *levels* in a full-featured EDACS system, each with different capabilities.

For example, in contrast with basic EDACS, full-featured trunking (level one) offers call validation, basic diagnostics, activity logging, automated background testing, telephone interconnect, call priority, management reports and more.

With a full-featured system, radios in the field can also be disabled and enabled remotely. This is of value when a radio is lost or stolen and subject to use by unauthorized

Ashley is a communications technician in Los Angeles.

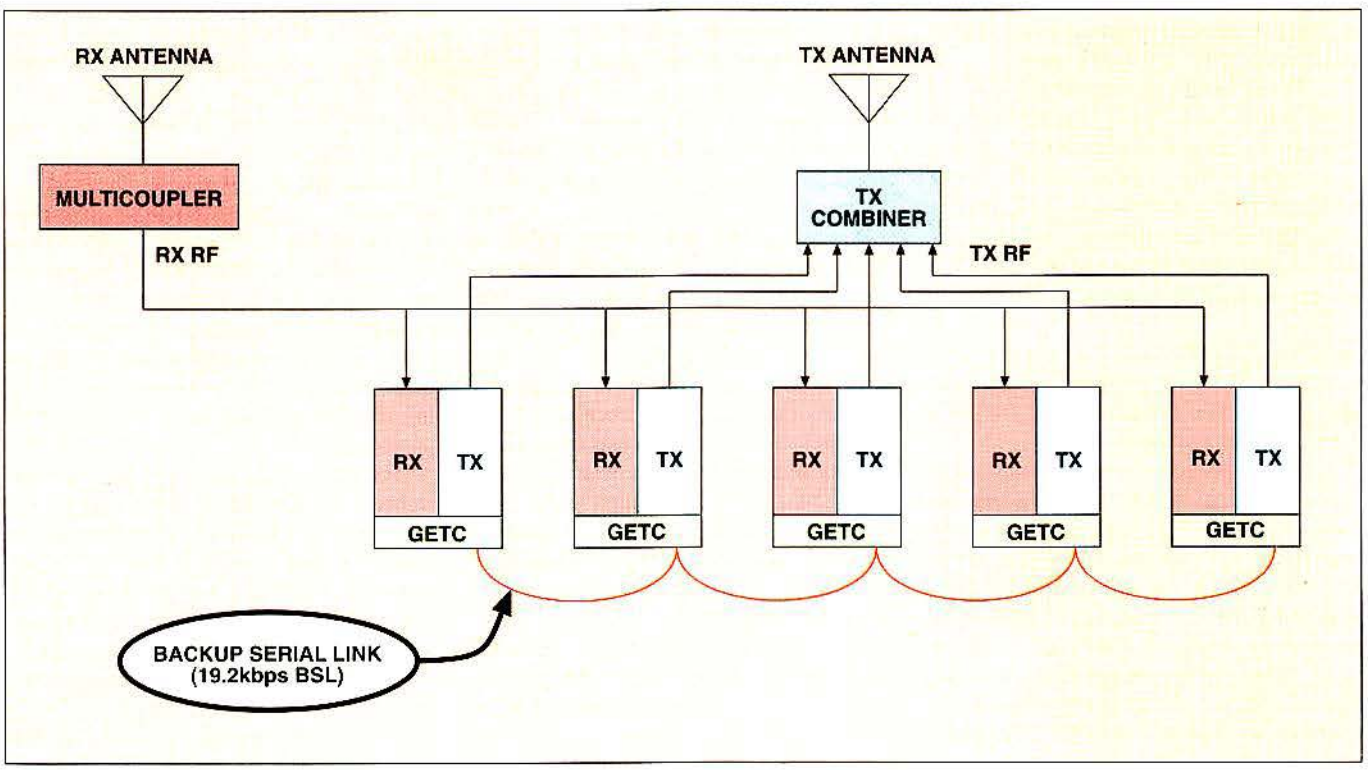

Figure 1. A five-channel EDACS system. The GETCs are connected via a 19.2kbps serial data link. The mulitple receivers use a single antenna and multicoupler. The multiple transmitters are combined and use a single transmit antenna. This basic form of EDACS operates in the trunked failsoft mode.

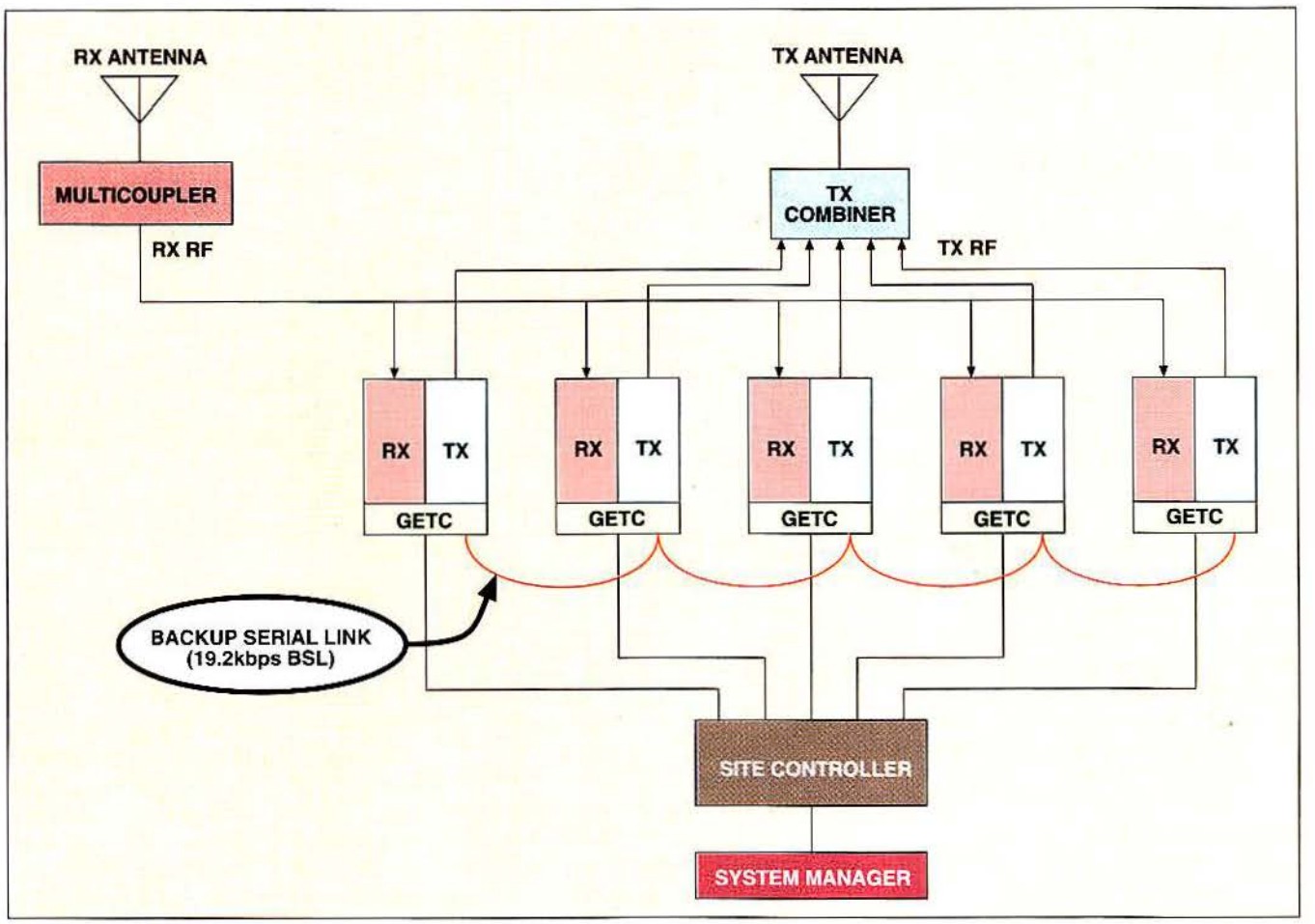

Figure 2. An EDACS system dedicated to a site controller.

personnel. Talk groups can be reconfigured dynamically. New talk groups can be created and radios in the field can be reprogrammed over-the-air at the rate of 30 per second to accomplish alternate grouping in the case of emergency, or for any other reason.

In the full-featured configuration, if the site controller fails, the individual base station GETCs can still handle normal trunking operations in the trunked failsoft mode (through distributed processing). In this event however, any additional functionality normally provided by the site controller and system manager will be lost.

Working channel/control channel

In an EDACS system, the channel assigned to handle the unit-to-unit traffic is referred to as a *working channel.*

However, prior to the actual unit-to-unit traffic, supervisory data transmissions between the user radio and the *controlling processor* (the station GETC, in basic EDACS, or the site controller in full-featured EDACS) must be accomplished in order to direct the user (and the units being called) to the proper channel in the system. This supervisory control is handled over a single, separate radio channel called the *control channel.*

The control channel acts as a conduit for the commands and requests being sent back and forth between the units in the field and the processor controlling system operations. In an EDACS system, one base station at the trunking site operates as the control channel while the others function as working channels. The control channel receiver acts as the system processor's "ears," listening for requests from field units. The control channel transmitter acts as the "mouth," sending channel assignments out to the units on the system.

When idle, the radios in the field stay tuned to the control channel transmitter frequency, monitoring the steady stream of supervisory data, waiting for instructions from the controlling processor that may apply to them. If a valid unit in the field transmits (keys up), the processor should recognize the unit and choose an available working channel for it, as well as for the unit(s) being called. Through supervisory instructions sent over the control channel, it will route these units to the assigned working channel, and communications through the system may begin.

When the calling party unkeys, the working channel is released and all involved parties revert back to the control channel to monitor the supervisory data.

If a user radio is turned on after a call for its group is already under way, it will have missed the *original* channel assignment information. One might assume that it would, consequently, miss the call. EDACS, however, is able to route "late arrivals" to the proper working channel because the supervisory data on the outbound control channel is repeated continuously. When a radio is first turned "on," it monitors the control channel. The repeating working channel assignment for that group will be received and will route the radio to the same channel as the other members of its group. This same method applies when a user has gone out of range of the trunking system. When back in range, the first thing the radio does is listen to the control channel information. Since channel assignments are repeated continuously, it will be routed to the proper working channel and pick up a call already in progress.

Normally, when a channel has been assigned and communications has begun, the initiating party has control of the channel. The other units within the same talk group cannot transmit during this period—they can only listen. This is called *transmitter-busy lockout,* and it eliminates malicious or unintentional interference to the initiating party by other units. The only way another group member can be heard during this period is to activate the radio's emergency button, triggering an *emergency channel request* transmission. The site controller will

then assign a different working channel to that group, dropping the original call and giving channel control to the user who initiated the emergency call.

Control channel protection

At an EDACS site, any base station in the multichannel system can function as the control channel. Typically, channel one is used as the control channel, however, if this radio or its associated GETC fails, the control channel duties can switch to another. Units in the field have the ability to scan all channels in the system to find the newly assigned control channel.

Trunking: transmission vs. message

In an EDACS system, when an assigned channel is released from one user, it becomes available to the next. Even if the same unit transmits again immediately after releasing a channel, the whole assignment process will repeat, starting "from scratch." This means the same group of users over a period of several transmissions are assigned a different channel in the system each time. This is referred to as *transmission trunking*.

Message trunking is when a delay or hang time is introduced after a user unkeys. The channel assignment can be maintained as long as users in the group continue to use the channel before the pre-programmed delay period expires. This is not an efficient mode of operation and can significantly impact the overall traffic handling capacity of a trunking radio system. Under certain conditions, however (such as an important dispatch or emergency call), it may be desirable to dedicate a channel to a particular group for a short period of time.

Call modes

In an EDACS system, there are three call modes: analog voice, digital voice and digital data. The analog voice mode uses a combination of high- and low-speed data (signaling) along with a standard analog voice transmission. In the digital voice mode, the analog voice is digitized and coded. Three coding schemes are available: Aegis, Aegis encrypted or Voice Guard. The last mode is the digital data mode where MDTs or laptops communicate through the system.

Call types

Group calls allow one individual within a group to contact other members of that same group. When the initiating party is assigned a channel, all units in the same group will be directed to that channel to hear the transmission. Other groups will not hear the call, only the members of the initiating party's group.

An *individual call* is when one individual wants a private conversation with another individual. In this type of conversation, no one can hear the conversation except the two parties involved.

Emergency calls can be made by pressing a special emergency button on the user radio. Although group calls are typically transmission-trunked, emergency calls are *message trunked*. When an emergency call is initiated, an audible alert signal is sent over-the-air to notify all units in that group as well as the dispatcher. Only the dispatcher or a radio equipped with *supervisory* functions can clear the emergency call.

A *system all-call* is where a specially equipped radio can communicate with *all* users on the system at one time. When the system call is placed, all active calls are dropped and assigned to a single channel. The specially equipped radio now broadcasts to everyone on the system.

The conclusion of this series will detail the step-by-step channel assignment process within an EDACS system and will reference basic simulcast considerations. ■

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A TNPP satellite-based simulcasting system for paging

Satellite–based simulcast paging provides solutions for crowded frequency and customer demand for larger coverage areas.

By Phil Anderson and James Taylor

What is simulcasting?

Simulcasting within a paging system is the process of synchronizing the emissions of the transmitters within the system's common coverage areas.

A typical three-transmitter, satellite-based system is shown in Figure 1 below and in Figures 2 and 3 on page 33. Distances from the geostationary satellite to cities *A*, *B*, and *C* range from 23,276 to 23,335 miles. Overlapping coverage due to pairs of transmitters on the ground is shown in Figure 2. If a pager is placed in the overlapping area between cities *A* and *B*, it must contend with two signals, one from each transmitter. For best pager performance, the signals from these transmitters must arrive at the pager at the same time. If they do, you have a simulcasting system.

Why simulcast?

Paging providers simulcast to send as many pages as possible in a given time segment and to ensure that their paging customers receive their messages. Consider Figure 2 again. If a provider does not simulcast, let's say with cities *A* and *B*, then all the transmitters for these sites must transmit one at a time. This ensures that a pager positioned midway between these transmitters will receive several copies of the page correctly. (System capacity is reduced, however, often to a third or a fourth of that for a simulcasting configuration.)

Typical TNPP satellite simulcasting

The equipment for a typical satellite-based simulcasting system is shown in Figure 3 on page 33. The system consists of a central paging terminal, a master (transmitter) paging controller and one or more slave paging controllers. Timing for simulcasting is controlled by the master controller. Command pages in telocator network paging protocol (TNPP) format, are sent from the master, via the paging terminal and satellite, back to itself and to the slave(s). The periodic command pages synchronize the master and slave controllers, telling them when to gather pages and when to transmit pages accumulated in their buffers.

How does the system work?

The paging terminal is central to this system, as it is to a terrestrial system. Pages are accumulated via dial-up telephone lines, from other terminals in adjoining cities in TNPP format and timing pages from the master paging controller. These pages are then uploaded to the satellite via the terminal's TNPP output port. In many cases, providers share the uplink with one of the providers acting as a hub. TNPP inputs to the hub—from adjoining cities—are generally sent via dedicated (continuously connected) data circuits.

The constant stream of pages from the satellite, in TNPP format, arrives at the master site and slave sites in the same order and at nearly the same time. The time difference, of course, depends on the distance from the satellite to each controller site. The pages are received at each satellite receiver and directed to the serial port of each controller. The controllers must sort and store the TNPP page traffic into destination buffers. Pages with destinations not listed in the controller tables are discarded. Each controller then encodes the TNPP pages into POCSAG format and transmits them simultaneously. Some systems may have several exciters (transmitters) at each site. With this configuration, the controller must sort TNPP pages into exciter-destination tables and key first one and then another exciter. Such systems enhance coverage, and pagers with different receive frequencies are accommodated.

Timing considerations

Reception by pagers situated directly between two transmitter sites is optimized, clearly if the paging signals from both sites arrive at the same time at the pager. CCIR recommendation 584 (Part 2 of *The Book of the CCIR Radiopaging Code No. 1*) specifies that these signals should arrive within less than 25% of the duration of one bit element of the page signal. For example, if your system is processing 1200-baud (1,200bps) POCSAG pages, then the difference in delay of the two

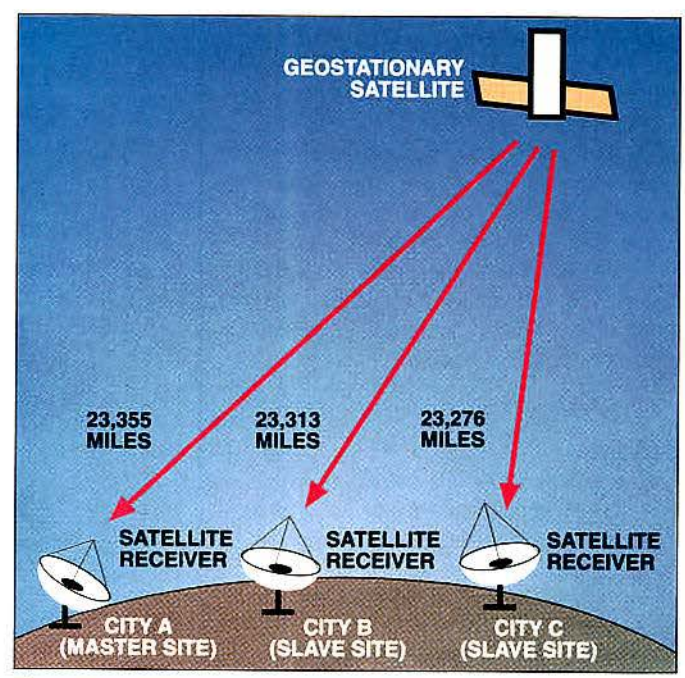

Figure 1: Satellite distance to sites

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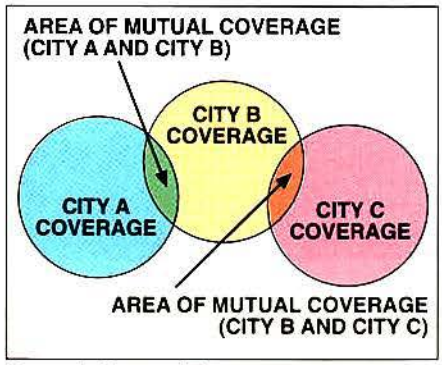


Figure 2. Terrestrial coverage areas.

signals should be less than 25% of 1/1,200th of a second, or 208μs. Sensitivity of pagers to the time difference of two identical paging signals depends, of course, on pager brand and model. All pagers following the POCSAG standard should meet this 25% criteria. We recommend that you set your system to achieve delays of less than 10%.

If two sites are separated from a satellite by a difference of 41.28 miles, as shown in Figure 1 and Table 1 for cities *A* and *B*, the pages retransmitted on VHF by these stations would arrive at a midpoint between them with a time difference of 206μs. Clearly, to meet the 10% criteria (or better), a delay must be added at the controller with the shorter satellite–earth path. Most controllers allow the paging technician to add this delay in one-mile increments, equivalent to roughly 5μs per mile.

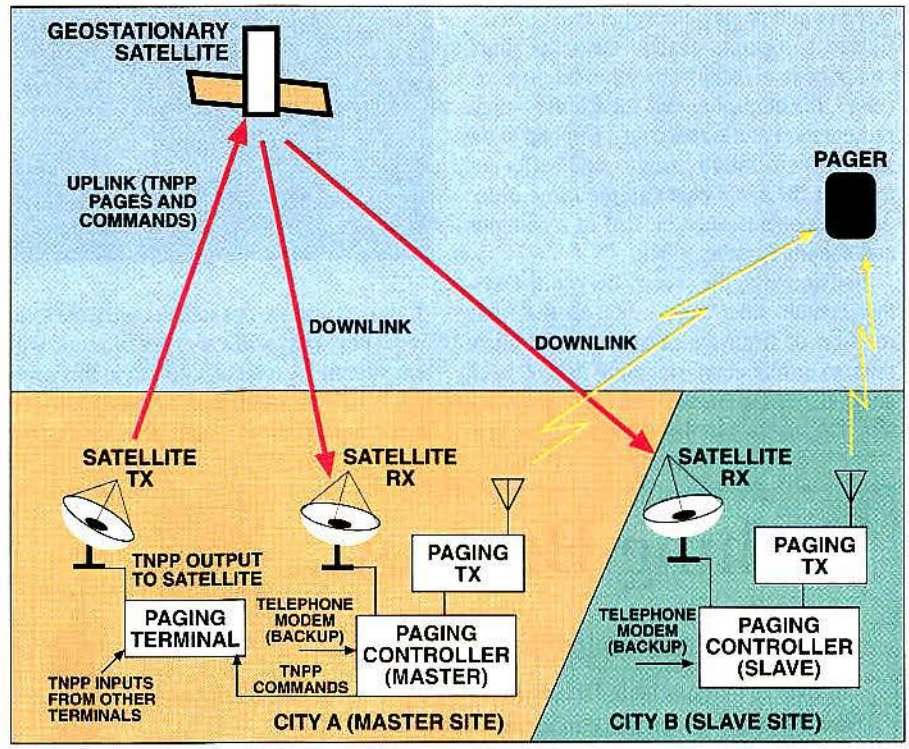


Figure 3: TNPP satellite-based simulcasting system

Equipment considerations

For the simulcasting system to work consistently (not just on the bench and not with just one, but several slaves), each satellite

receiver and paging controller must be configured to operate exactly the same. Each component at each site—the satellite receiver, the controller and the exciter—must present the same signal delay, respond to the same to temperature changes, and buffer and transmit the same pages in the same order. All components must be tied to a common and accurate timing clock.

For example, the controllers in the system contain microprocessors, so the same revision of firmware must be run in all of them to ensure equal signaling delays. Each controller has its own crystal oscillator clock too. The crystals in these units are not synchronized and are not set at exactly the same frequency. They will vary over time and with temperature. A typical solution to this problem is to synchronize all of the controllers to a common clock using phase-lock loop (PLL) techniques. If the satellite receivers have a clock that is accurate and stabilized (kept on frequency) by a PLL based on the incoming page data stream, that clock may be used. Clock accuracy must be within 0.1%. If not, a common clock can be derived from a Global Positioning System (GPS) module.

Table 1. Mileage difference between sites and site farthest from satellite.

CITY	MILES FROM SATELLITE	MILEAGE DIFFERENCE	TIME DIFFERENCE	FRACTION OF BIT TIME FOR 1200 BAUD
CITY A	23,355.00	0	0	0
CITY B	23,313.72	41.28	0.206msec	0.25
CITY C	23,276.57	78.43	0.392msec	0.47

System installation and testing

Once a system of master and slave controllers is in place, a satellite uplink path for the TNPP command packets from the master controller must be established, and time delays to equalize the satellite-to-controller distances must be fine-tuned. Destination tables within the paging terminal must be reprogrammed to accept input-only TNPP command packets from the master paging controller and route them to the terminal's TNPP output port. The output port may feed a satellite uplink directly or via another paging terminal (in another city) connected by a phone line. In the latter case, destination tables allowing command packets from the "master" controller source address may need to be entered.

The simplest way to check that the satellite-site delays are roughly equal is to take a pager to the common coverage areas and send it pages. A good double-check is to haul along a service monitor to display and listen to the pages received. If a pair of simulcasted signals sounds as "clean" as the transmission from one site, then the system is tuned.

With crowded frequencies—often being shared by two or more paging providers—and with customer demand for larger coverage areas, simulcasting by satellite makes sense. While providers do use terrestrial-based simulcasting systems (with a 72MHz control link sending POCSAG pages to a number of transmitters incorporating audio delay lines to equalize distance) satellite-based systems offer simpler installation and easily incorporate traffic from other providers.

For those concerned with satellite rain fade or longer term loss of satellite feed, automatic telephone line back-up systems can be easily installed. ■

product/services showcase

The following pages contain mobile radio, paging, cellular products and services of advertisers in this issue. Information is provided by the advertisers. For more information on these products, circle the corresponding Fast Fact number found on the card on page 65, or contact the advertiser directly. Also, refer to the Advertiser Index on page 64 for the page reference to the company's advertisement.

Management software

Intracom from **Alphalogic Systems** is management software for mobile electronic dealerships. Track a radio from the time it leaves your office, knowing every warranty repair, routine service and resell. Tie it all together with AR, AP and GL. The software was developed by radio dealers for radio dealers.

Circle (301) on Fast Fact Card

Custom labels

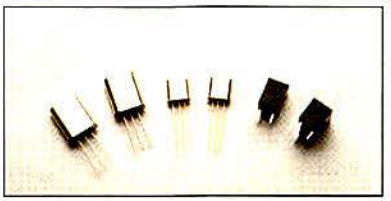
Anchor Graphics specializes in the communication industry. Its product line includes pager, radio and cellular labels, bar codes, tamperproof frequency labels and the new improved code-a-label software to manufacture your own labels for pagers, as well as all types of custom label applications.

Circle (302) on Fast Fact Card

Optimizer

ESMR, cellular, paging and PCS operators now have an easier way to optimize their systems. The **Celwave** Optimizer, a log periodic dipole antenna, offers continuous adjustment of electrical downtilt with the simple turn of a dial. One Optimizer operates over a frequency range of 1,850–1,990MHz and has a 11.5dBd gain and a 90° horizontal beamwidth.

Circle (303) on Fast Fact Card



Crystal Filters

Communication Specialists has produced low cost, exact replacement narrowband crystal filters for 10.7MHz, 11.2MHz, 11.7MHz, 21.4MHz, 21.8MHz and 45.05MHz. For more infomation visit the Web site at *www.com-spec.com* for the complete catalog and product descriptions

Circle (304) on Fast Fact Card

Auto remote

Connect Systems' Auto Remote turns PBX/KSU extension phones into a radio remote allowing dispatch to all radios in an on-premise radio system. CSI Model 6800 allows instant emergency communications in hospitals, resort hotels, commercial office buildings and warehouses.

Circle (305) on Fast Fact Card

Circle (29) on Fast Fact Card

product/services showcase

Direction finder

The 6000/6100 series radio direction finding systems from **Doppler Systems** feature 2° accuracy, operating range 125 to 1,000MHz. Software facilitates data acquisition from multiple sites and features real time triangulation of signal source locations on digital maps.

Circle (306) on Fast Fact Card

Narrow notch

The **Eagle** TNF-400 tunable filters provide <0.7% notch width with notch depths of >30dB. Frequencies available are 10 to 500MHz. Units will pass up to 1.0GHz. Package size is 3" × 2". Call for free application note. 520-204-2597.

Circle (307) on Fast Fact Card

Site monitoring

Hark Systems manufactures tower site monitoring and card access equipment. The Hark TSM-2000 can be applied to sites and can provide the manager with an alarm reporting platform that can be optioned to control entry to buildings, monitor existing light, control entry to buildings and provide one point for reporting site alarms and conditions.

Circle (308) on Fast Fact Card

Power switching supplies

The **ICT** High Power series switching power supplies operate at 100% continuous peak power. They feature auto-adjusting input voltage of 90Vac–270Vac, power factor correction, internal voltage control and diode protected output. The 40A, 60A, and 80A models are available in a desktop, rackmount.

Circle (309) on Fast Fact Card

Dispatch networking

Low-cost dispatch networking of LTR format from **IDA** is now available. Net-link with Word Saver is simple and convenient for customers. No microwave phone lines or signaling are needed. Call 800-627-4432.

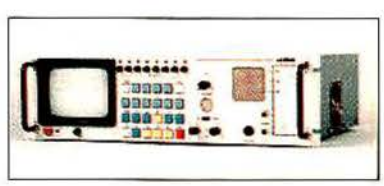
Circle (310) on Fast Fact Card

IFR Americas, Inc.

Wireless testing

With the acquisition of the former Marconi Instruments and IFR complete, **IFR Americas** is a wireless test provider. The company's radio test sets, spectrum analyzers and signal generators are used to design, install and maintain cellular, PCS, SMR, private wireless, paging and microwave applications.

Circle (311) on Fast Fact Card



Voice recorder

JEI's digital voice recorder logs your critical communications with a JEI DVR-8. This instant recall/archival system records hundreds of hours of telephone or two-way radio conversations. The built-in monitor allows you to view 12 lines of data at one time.

Circle (312) on Fast Fact Card

Lightning protection

PolyPhaser introduces the next generation in lightning and surge protection for the rapidly growing personal communications services market with its patent-pending Micro PSX series.

Circle (313) on Fast Fact Card

Portable transceiver

Premier Communications announces a palm-sized, portable transceiver for conventional VHF low band applications. The PR-45 has 99 channels, a LCD, and covers 38MHz–50MHz with 5W RF output. Models are also available for 136MHz–174MHz and 450MHz–470MHz. Call 1-800-666-2654 for more information.

Circle (314) on Fast Fact Card

RITRON, INC.

Radio communications equipment

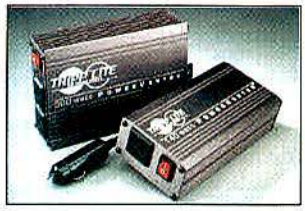
Ritron is a United States manufacturer of radio communications equipment. Products include Jobcom jobsite radios, VHF low/high & UHF conventional and LTR/Passport trunking portables, mobiles and repeaters. Other products include wireless telemetry systems and RF data modules. Ritron is a family-owned business headquartered in Indiana.

Circle (315) on Fast Fact Card

Paging transmitters

SONIK Technologies' high-performance synthesized paging transmitters are designed for continuous duty operation. They are suitable for the most demanding on-premises paging systems and are often used as exciters in public paging networks. Both VHF and UHF models are available.

Circle (316) on Fast Fact Card



Inverter

Tripp Lite Powerverter ultra-compact dc-to-ac inverters provide 120V ac power wherever and whenever needed by harnessing the battery power of automobiles and RVs. Powerverter ultra-compact inverters supply power for laptop computers on the road, household appliances at campsites and small power tools at worksites.

Circle (317) on Fast Fact Card

Collinear array antenna

TX RX SYSTEMS INC.
A member of Bird Technologies Group

TX RX Systems, a division of Bird Technologies Group, is offering three versions of its broadband collinear array antenna for the 860MHz–960MHz range. Each model is an antenna featuring bandwidth and pattern consistency, along with 1,000W power handling capability.

Circle (318) on Fast Fact Card

IDEN remote control

The **Zetron** Z370 is a desktop remote that controls an IDEN radio located as far as 2,000 feet away. Whether the user is calling a talk group or just checking for mail, the Z370 is easy to understand. For facilities with multiple dispatch points, the remote provides additional functions.

Circle (319) on Fast Fact Card

IWCE '99
International Wireless Communications Expo

April 28–30, 1999
Las Vegas Convention Center
Las Vegas, NV

Call for Conference Session Moderators!

Moderators are needed for sessions, or to help organize sessions on a subject of their special interest.

Projected session topics include:

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Mobile Radio Technology
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Email: *don_bishop@intertec.com*
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Is your instrument fooling you?

By Harold Kinley, C.E.T.

Have you ever had times when you just couldn't believe what your test equipment was telling you? If not, you probably haven't been working in the field of electronics very long. Test equipment is getting more and more reliable as far as accuracy is concerned. However, the point has not yet been reached where test equipment is totally infallible. There are many things that you can do to keep your equipment *more or less* calibrated. We will take a look at some of the methods that can keep your test gear from taking you on a wild goose chase.

Bessel-zero method

The Bessel-zero method is great for checking the calibration of your deviation-measuring instruments. According to Bessel functions, when a carrier is frequency-modulated at various values of modulation index the carrier will be completely nulled out. For our purposes in land mobile radio we need only be concerned with the 1st and 2nd nulls occurring at modulation indices of 2.405 and 5.52.

Photo 1. An unmodulated carrier at a level of about –28dBm.

Photo 2. A frequency-modulated carrier with a modulating tone of 1kHz. The FM sidebands appear around the carrier at a spacing equal to the frequency of the modulating tone—1kHz in this case. The carrier is at a level of about –40dBm.

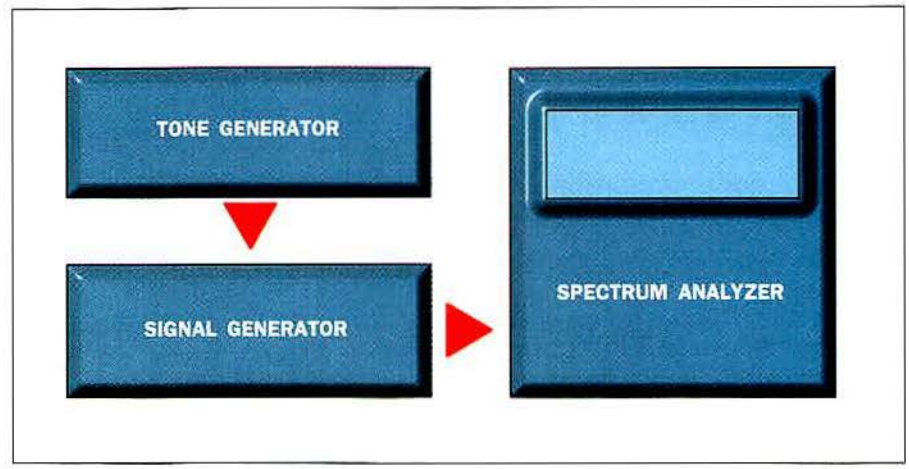


Figure 1. This setup can be used to check the accuracy of a deviation measurement using the Bessel-zero method.

Before going further into this method, let's look at the definition of *modulation index*, which can be determined mathematically by dividing the frequency deviation by the modulating frequency. If a modulating tone of 1kHz is applied to an FM transmitter and causes a deviation of 2kHz, then the modulation index is 2.0. As long as we use a 1kHz *modulating* tone, the modulation index is easy to calculate. It is equal to the frequency deviation in kilohertz. This is one good reason for using a 1kHz modulating tone for such a test. The other good reason is that an accurate 1kHz tone is easy to come by because it is used so frequently in transceiver testing. Most service monitors, as well as SINAD meters, provide an accurate 1kHz tone source.

Suppose you want to check the accuracy of your service monitor's deviation calibration. See Figure 1, above. Start with an unmodulated carrier and, using a 1kHz modulating tone, gradually increase the deviation level until the carrier disappears, leaving only the 1kHz-spaced sidebands. At this point, the deviation level is 2.405kHz, and this is what the service monitor should indicate, as shown in photos 1 through 4 on pages 48–49.

The spectrum analyzer must have sufficient resolution to resolve the 1kHz sidebands into separate and distinct displays on the spectrum analyzer. Without sufficient resolution, you will not be able to tell when the carrier has been nulled out.

Once the deviation increases above 2.405kHz, the carrier will reappear and will null again at 5.52kHz. The first two nulls are all we need to be concerned with for checking the calibration of instruments for land mobile radio. If your deviation meter indicates anything other than 2.4kHz at the first null, then your instrument needs calibrating. Double-check this at 5.52kHz for the 2nd null.

What about the accuracy of the 1kHz modulating tone? It is important that the modulating tone be accurate. The accuracy of the modulation index will follow the accuracy of the tone frequency. For example, if the 1kHz tone is actually 995Hz, then this represents an error of 0.5%, and your results from using this modulating tone will be in error by 0.5%. This represents an accurate calibration for a deviation meter, one that I will gladly accept for servicing purposes.

SINAD meter

It is a good practice to check your SINAD meter frequently to make sure that the tone used for SINAD measurements is centered in the notch of the SINAD meter. If the 1kHz tone is not accurate, or if the notch filter is not properly tuned to the tone frequency used for SINAD measurements, the accuracy of the measurement will suffer. To ensure that the tone you are using for SINAD measurements is centered in the notch of the filter, feed the tone directly into the SINAD meter and observe the SINAD reading, which should indicate 24dB SINAD or better. *More* is better! Adjust the frequency of the tone up or down a few hertz to see if any improvement can be made. If so, check the tone

Kinley, a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewylde Drive, Spartanburg, SC 29301. Kinley's email address is *hkinley@aol.com*.

frequency against one known to be accurate. If the tone frequency is accurate, adjust the notch of the SINAD meter for best SINAD reading (maximum null of the 1kHz tone). Tone generators built into SINAD meters are accurate. For example, the Helper Instruments' S105 tone generator is accurate to ±1Hz.

If you are ever in doubt about the accuracy of your service monitor frequency measurements, there is a simple way in the field to get a quick rough check on the calibration. Through the years, I have noticed that one of the television stations in my area seems to keep tighter than other stations. I have come to rely on this station to occasionally check my service monitor's frequency calibration. This particular station has its visual carrier at 175.26MHz. I have never seen more than a 40Hz disagreement between my service monitor and this television signal. If I am out in the field and have a need to check on my frequency monitor, I can easily tune in this television signal for reference.

Summary

I don't mean to imply that by using these methods you will never have to send your service monitor off to the factory for recalibration to factory specifications. But on occasion you can use these methods to keep on track and avoid a frustrating and often time-consuming wild-goose chase. By making frequent checks on your test equipment, you can also avoid the embarrassment of improperly adjusting customers' radios to your inaccurate test equipment.

Maxtrac repeater response

First, a couple of notes about the Maxtrac repeater combo column that appeared in November 1998. Jack Tibbetts of Cellular One in Boston pointed out that the diode labeled "2N4148" should be "1N4148." That's correct Jack and thanks for pointing it out. I hope that didn't confuse too many of you. Rob George wanted to know if the same kind of arrangement could be made with GM300 model radios. Coincidentally, Earl S. Garber emailed to say that such an arrangement could be done with Radius or GM300 models using the 16-pin connector on the back without making any internal modifications to the radio. Earl also said that a 4.7k resistor seems to reproduce the deviation better than a 1.8k resistor. Thanks to all who emailed comments, and good luck with your individual projects.

Until next time—*stay tuned!* ■

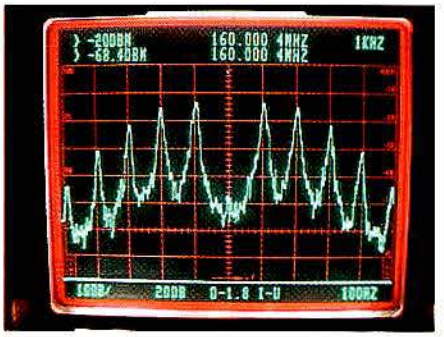


Photo 3. Here the carrier is nulled out at about –68dBm. This is about 40dB down from the unmodulated condition shown in Photo 1. This indicates that the deviation is at 2.4kHz.

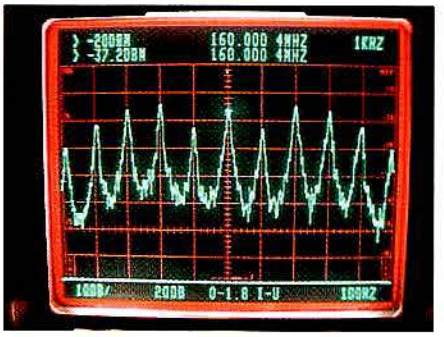


Photo 4. Here the deviation is increased beyond the 2.4kHz level and the carrier emerges. It will null again at 5.2kHz deviation.

First 900MHz wide-area network launches in Iowa

Electronic Engineering of Des Moines, IA, launched the first commercial, 900MHz wide-area network in Iowa in October 1998. The system, designed over a two-year period, was completely operational at the time of the public announcement and offer of service.

The Star 900 network covers most of Iowa. The footprint extends into eastern Nebraska, providing two-way service from Des Moines to Lincoln, NE. The system is based on a 900MHz E.F. Johnson LTR-Net backbone from Transcrypt/E.F. Johnson.

The association with Johnson equipment is a shift for Electronic Engineering, which has been predominantly associated with Motorola for two-way radio and paging sales and support for more than 50 years.

"This relationship is certainly a departure from what we've done in the past," said E.E. President Mark Clark.

Transcrypt chairman John T. Connor was present for the launch announcement. He said that Transcrypt/EFJ, which both consulted on the network design and supplied equipment, was "pleased and proud to launch this first system in Iowa with Electronic Engineering because of their technical expertise and reputation for high-quality service." Clark said the network was a response to the needs of customers with geographic needs beyond single-site coverage.

CONGRESS AND PRIVATE WIRELESS—Industrial Telecommunications Association President Mark Crosby (left) hosts a congressional policy forum with Mark J. Ashby (center), counsel to Sen. John Breaux (D-LA) and Andrew W. Levin, U.S. House Commerce Committee Democratic counsel, at ITA's annual meeting in Washington, Oct. 29, 1998. The panelists discussed FCC misinterpretation of Congressional intent regarding expanded auction authority and that any auctioning of private wireless spectrum would exceed that authority.

FCC Notes

Chief of staff steps down

John Nakahata, chief of staff to FCC chairman William Kennard, left the agency late last fall. Nakahata said that he wanted to spend more time with his family.

Prior to becoming chief of staff last November, Nakahata served as legal adviser and senior legal adviser to then-chairman Reed E. Hundt. Nakahata had been a key adviser on challenging issues facing the FCC. Following enactment of the Telecommunications Act of 1996, Nakahata was a principal architect of the commission's "trilogy" of interconnection, universal service and access reform decision. He led the negotiations that formed the foundation for the *Universal Service Order*. Nakahata said that he had not yet set any future plans.

FCC forms third joint agreement

The FCC has signed the latest in a series of *Memorandums of Understanding* (MOU) with private industry regarding the resolution of interference complaints. This agreement was coordinated by the FCC's Compliance and Information Bureau (CIB), working in conjunction with the FCC Wireless Telecommunications Bureau and the Association of American Railroads (AAR). The main objective is to facilitate the commission-certified frequency advisory committee's (FAC) work in concert with CIB to protect the technical and regulatory integrity of radio communications. This is the third such agreement between the commission and industry designed to streamline the commission's compliance and enforcement processes regarding interference complaints on communication frequencies formerly used by the Railroad Radio Service.

Commission denies relief petition

James A. Kay, licensee of 152 Part 90 Licenses in the Los Angeles area, filed a petition for extraordinary relief that was denied by the FCC. The commission had received numerous complaints about Kay's operations. Following further proceedings, a summary decision revoked Kay's licenses and ordered Kay to pay a $75,000 fine. The decision was vacated, and the proceeding was remanded for a hearing. Kay argued that the hearing should not go forward because of alleged improprieties by the bureau during the pre-designation phase of this proceeding. Kay asserted that those actions deprived him of due process and filed a petition in June 1998. It was taken into consideration and denied.

However, a new administrative law judge has been appointed to the case because of disagreements that arose between the former judge and Kay's legal counsel.

Vermont installs digital E9-1-1 network

Vermont is the first state to use an all-digital, statewide network for public safety emergency response calls, after installing eight Lucent Technologies digital systems to handle E9-1-1 calls.

Lucent Public Safety Systems, a venture of Lucent located in Lisle, IL, worked closely with Bell Atlantic to complete the installation of the E9-1-1 systems under a $7.4 million contract from the state. The digital systems, or public safety answering points (PSAP), allow 9-1-1 call takers to receive emergency calls, obtain the caller's name, location and problem and then alert the proper fire, police or EMS in the caller's local area.

The system is designed to decrease call set-up times from about 10 seconds to less than two seconds.

The Vermont E9-1-1 network now includes eight new calling centers: one large PSAP center in Williston and seven smaller centers in Rutland, Springfield, Hartford, Lamoille County, St. Albans, Shelburne and Montpelier.

Each PSAP workstation integrates voice and data information to make routing operations faster and simpler.

AMTEX 98 addresses industry's critical issues, problems

More than 150 attendees at November's AMTEX '98 in Miami Beach were reminded that the only constant in the mobile communication industry is change. The conference focused on current trends in the regulatory landscape, increased competition, spectrum issues and new technology.

Steve Virostek presented The Strategis Group's preliminary findings on the latest SMR industry survey. Latest results predicted continued growth in the SMR industry, 900MHz, 220MHz and 450MHz trunking. Virostek reported that heightened distribution and consumer awareness, as well as lower airtime prices, are spurring competition and subscriber growth. One long-term implication for the industry in the absence of spectrum allocation is the need to implement capacity-enhancing technology.

TEXAS FREQUENCY RANGERS—Texas public safety communications, emergency number and records management professionals met in Lubbock, TX, in October 1998, for a combined TX APCO–NENA–TCJIUG conference and exhibition. The conference drew about 400 attendees and more than 40 exhibitors.

Attendees at the 450MHz trunking session discussed problems caused by the lack of spectrum exclusivity and ways to find a temporary solution until a permanent one can be implemented. The session was moderated by Ralph Haller of Fox Ridge Communications. Panelists included Bart Fisher of Fisher Communications, Rhett Grotzinger of Trident Micro Systems, Craig Johnson of Smartlink, John Osler of Uniden and John Sullivan of SmarTrunk Systems.

Sessions offered coverage of some of the industry's critical issues: 900MHz interference, 450MHz trunking, interference, tower issues, Y2K and a post-auction wrap-up. Attendees were briefed on a variety of regulatory issues, including number portablility, universal service, CALEA, the 800MHz auction, Goodman/Chan and refarming.

Twenty-nine, a record number of exhibitors, were present at this year's AMTEX. ComSpace discussed its DCMA digital technology. The conference was held in conjunction with IMTA's International Congress on Trunked Radio.

LCC, Allen Telecom terminate agreement

LCC International, McLean, VA, and Allen Telecom, Beachwood, OH, have mutually agreed, in writing, not to proceed with the previously announced transaction for LCC to exchange its test and measurement equipment and related software analysis tools business for engineering, software and consulting business of Allen Telecom's Comsearch division.

Rajendra Singh, interim chief executive officer of LCC, said, "During the due diligence period, both parties re-evaluated the strategic nature of their respective businesses."

Singh said that LCC's Hardware Products group had been through a "tough period" due to sales and profitability. "We will realign the Hardware Products organizations along with the rest of our company in light of changing market conditions, and I am convinced that we will restore the entire company's profitability to the levels that I and other shareholders expect," he said.

Robert G. Paul, president of Allen Telecom said, "Both Allen Telecom and LCC International devoted a significant amount of effort in pursuit of an agreement. However, we came to the judgment that our shareholders would be better served by retaining our Comsearch business ...."

News Notes

Coded Communications, Carlsbad, CA, announced an agreement to acquire Boston-based **NetCore Technologies**, an international provider of remote network management and desktop support services. Under the terms of the agreement, NetCore will exchange all of its assets, liabilities, technologies and licenses for shares of Coded common stock. **Brian Williams**, president of NetCore Technologies will become chief operating officer for Coded Communications. Steve Stevenson, founder and chairman on NetCore will serve as Coded's interim president.

Williams

Williams said, "The potential for expanding and integrating Coded's extensive mobile networking experience and wireless products with NetCore's value-added applications and network management services is nearly limitless."

Intek Global, Princeton, NJ, sold non-core, UK-based land mobile radio equipment distribution and maintenance assets to **Securicor Information Systems** (SIS), a subsidiary of Securicor plc. SIS will act as a major UK and European distributor of Intek Global's LM products to capitalize on the rapidly growing move in both markets to narrowband transmission.

Robert J. Shiver, Intek Global chairman, said, "This is another important step in our continuing effort to focus Intek Global's future on the commercialization of our valuable spectrum-efficient LM technology and the offering of superior data and voice capabilities to the booming worldwide wireless communications industry. In addition to providing Intek Global with a capital infusion, the sale enabled us to divest assets that did not fit into the Intek Global strategy."

Chadmoore Wireless Group, Las Vegas, achieved record revenues for the three-month period that ended Sept. 30, 1998. Chadmoore is also loading its SMR services in 82 markets. Revenues were up 112% from the same three-month period in the previous year.

Chairman **Robert Moore** said, "As the second-largest holder of frequencies in the United States in the 800MHz band for commercial SMR service, we have been in a unique position during the past few years to identify and take advantage of major changes in this segment of the wireless business. We are providing a marketing focus to a business previously dominated by companies more comfortable with technology than with selling, and with so many channels we are adding efficiencies not previously available to small operators."

Ritter

Under an agreement with **Iridium North America**, **PageNet** will be the exclusive wireless messaging provider to distribute Iridium global satellite paging services in the United States.

Douglas R. Ritter, senior vice president of corporate development for PageNet said, "Iridium wireless messaging users will be the first to realize the power of true global access, at a level that leaps ahead of any mobile communication alternative today."

Walz

Jim Walz, president of Iridium North America, added, "With its distribution network and its standard for service, PageNet is in the best position among wireless messaging providers to build the market for Iridium paging services in the United States."

220MHz auction closes; $21.6 million raised

The Federal Communications Commission's 220MHz-service auction closed on Oct. 22, 1998, after 173 rounds raising $21,650,301 in net high bids. The auction, which began on Sept. 1, 1998, represents the FCC's 17th auction.

"The commission's flexible rules for the 220MHz service will allow companies to provide whatever voice, data or fixed communications services they believe will serve the needs of consumers in their area. This could include services such as dispatch or paging," said Chairman William Kennard. "This auction has been a prime example of what the commission's auctions are all about. New and existing players have had a chance to quickly acquire licenses and take their place in the telecommunications marketplace of tomorrow."

Small businesses won a significant amount of the licenses sold at the auction, according to the FCC. Companies claiming small business status won: 67% of the Regional Economic Area Group licenses, 54% of the Economic Area licenses and one of the three nationwide licenses. Twenty-five licenses were sold to entities claiming women-owned status, and those claiming minority-owned status won 21 licenses.

Of 908 licenses simultaneously auctioned in three different-sized geographic areas: three are nationwide licenses, each authorized to use 100kHz, paired, of bandwidth; 30 are Regional Economic Area Group licenses (five licenses in each of the six regional economic areas) each authorized to use 155kHz, paired, of bandwidth; and 875 economic area licenses (five licenses in each of the 175 economic areas) each authorized to use 100kHz, paired, of bandwidth. This auction represents Phase II of the licensing of this band. Phase I licensing was conducted by lotteries in 1992 and 1993.

Of the 908 licenses auctioned, 693 were sold. A reauction of unsold licenses is likely to take place in the second quarter of 1999. Details of the 220MHz reauction will appear in a future Wireless Telecommunications Bureau notice.

PHASE II 220MHZ AUCTION–TOP 15 BIDDERS BY NET BIDS

BIDDER NAME	NET $	# HIGH BIDS	# POP'S COVERED
Intek License Acquisition	12,153,407	181	1,058,094,790
SOPHIA Licensee	3,158,545	11	400,454,773
Net Radio Group	1,124,370	126	274,606,930
Two-Twenty Auction	884,455	18	209,774,127
220MHz Building Consortium	728,175	37	114,629,334
Intellicom Bidding Consortium	417,105	19	112,411,736
Philip Adler	397,995	6	64,612,057
Longhorn Communications	390,608	21	109,467,801
Repeater Network Spectrum	377,500	39	61,166,374
S.K. Warren Communications	354,250	6	33,858,490
Nextel 220 License Acquisition	266,079	68	58,120,985
KDR	265,525	18	42,895,863
Radio Comm Services	175,110	5	6,702,304
Berkeley Electric Co-op	137,000	18	11,731,166
Mobile Communications Services	85,150	1	4,538,394

Larsen Electronics changes name

Larsen Electronics, Vancouver, WA, has announced plans to become Larsen Antenna Technologies. This change reflects Larsen's focus on antenna design for a wide array of wireless applications.

The company's Canadian subsidiary will be known as Larsen Antenna Technologies–Canada, Ltd. Located in Burnaby, British Columbia, this division serves all Canadian provinces and the Pacific Rim.

Monarch Capital invests in ACT

Monarch Capital Partners has signed a deal to invest $3 million in Advanced Charger Technology (ACT). The Norcross, GA–based ACT currently manufactures battery chargers but is transitioning its focus to embedding its patented battery management technologies into all types of rechargeable devices from power tools to wireless telephones. Monarch Capital Partners specializes in early-stage to mid-stage venture capital investments and plans to invest $30 million in emerging Internet, telecommunications, software, high-tech and biotech companies in the Southeast.

Motorola, Daniels enter license agreement

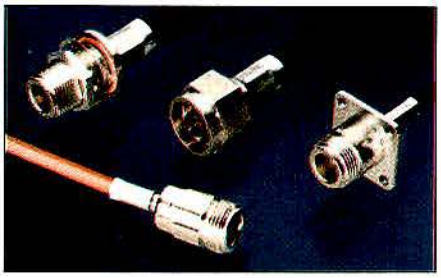
Motorola's Commercial, Government and Industrial Solutions Sector and Daniels Electronics of Victoria, British Columbia, have announced a new agreement in which Motorola will license to Daniels selected digital communications technologies compliant with the Project 25 digital standard for public safety communications systems. The agreement enhances Motorola's original licensing agreement of Project 25-compatible technologies to Daniels that was announced in 1996.

Daniels will use the Motorola technologies to enhance and broaden its existing product line to include Project 25-compliant modular base stations, repeaters and transportable radio systems.

According to company president Terry Daniels, the agreement will have immediate benefits for Daniels' customers.

Connectors

Crimp connector withstands shock



The N series II connector from **AMP** can withstand shock and vibration to assure low noise levels and has a constant impedance of 50V. It features a captive center contact and provides performance to 11GHz. N series II connectors are available in straight and right-angle plugs and straight, panel and bulkhead jacks. The collars are available in both hex and knurled versions, and the connector uses a hex crimp.

Circle (351) on Fast Fact Card

Coaxial connectors assemble straight-, right-angle

Tru-Connector's 7/16 series RF coaxial connectors include plugs, jacks, panel receptacles, between-series, in-series, T-style and right-angle adapters and combination connectors that can be assembled in either straight or right-angle styles. Featuring a 7/16 panel receptacle with an "N" connector footprint to save panel space, these connectors are available individually or as complete cable assemblies from 0.141" up to 0.875" in varying lengths. Constructed from silver-plated brass bodies, beryllium-copper contacts and teflon insulators, the connectors conform to DIN 47223, IEC 169-4, VG 95250 and CECC 22 190 specifications for all mating dimensions. Providing 50V impedance, they have a dielectric withstanding voltage of 4,000Vrms and 10,000mV (min.) insulation resistance.

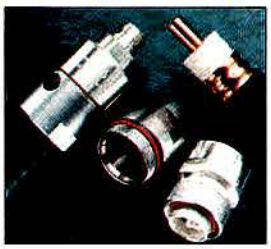
Circle (353) on Fast Fact Card

Male connector features silver-plated body

The RFN-1006-2L2 N male crimp connectors from **RF Industries** are designed for use with LMR-600 low-loss cable from Times Microwave. This connector features silver-plated body, gold-plated contact and teflon insulation and is engineered to perform within the full frequency range of the LMR-600 cable. Also available for shipment is the RFN-1002-2L2, and N male solder clamp connector and the RFN-1024-2L2, an N female crimp connector.

Circle (354) on Fast Fact Card

Connectors minimize IM distortion



Eupen Cable USA's EC3 premium connectors for corrugated copper cables minimize passive intermodulation distortion. The levels produced by the 7/16 DIN connectors have been tested and independently verified to be lower than 3160dBc, as required for GSM and other sophisticated wireless communications antenna feeder applications. To achieve these levels, the EC3 connectors use spring contacts for both center and outer conductors to maintain high-contact pressure over time. The connectors also use a non-flush cut attachment method, eliminating the risk that copper particles that will be introduced into the dielectric, which can occur in traditional, flush-cut method. Long-term performance is ensured by the use of a silicone RTV to seal between the cable and connector, providing waterproof sealing, which is not the case with o-ring sealing. All electrical path parts of these connectors are silver plated.

Circle (352) on Fast Fact Card

Test set gives complete control

IFR Systems' 29-59 advanced multi-mode cellular phone test set weighs 26 pounds and combines feature sets with AMPS, NAMPS, TDMA (IS-54/IS136A) cellular and CDPD test capabilities as standard. For accurate TDMA handset checks, the 2959 supports VSELP and ACELP vocoder testing, digital transmitter modulation IQ analysis, handset DTMF signaling and TDMA time slot change measurements. For AMPS and NAMPS handset testing, the instrument measures both transmit and receive functions. Tests include call registration, handoffs, page responses, SAT/ST frequency error, antenna/cable loss tests. The CDPD test mode simulates mobile data base stations (MDBS) and mobile data intermediate systems (MD-IS), which allows testing of CDPD wireless modems. In the automatic mode, the 2959 allows the user to control which tests are performed as well as the pass/fail parameters for each test. The manual mode provides the versatility to troubleshoot specific parameters. It has an intuitive user interface and simplified test setup procedures.

Circle (401) on Fast Fact Card

READERS' CHOICE

Of the new products in the May 1998 issue, these products generated the biggest reader response. For more information on these products, circle the corresponding Fast Fact Card numbers on the card found in the back of this issue, and mail the card to us.

Grounding straps on a roll offer flexibility in bonding, termination

Electric Motion's Microbond 2000 series, tinned copper rope-lay cable with pure copper terminations, offers flexibility in bonding and grounding. Equivalent to a #6 AWG, Microbond has standard terminations every four inches, with ¼" mounting holes. It comes on a 25 feet roll, so it can be cut to any length with scissors. Its design provides for easy installation. It terminates like any standard connection. Factory-installed terminations (one-piece for greater conductivity) provide maximum pull-out strength. Continuous loop eliminates the need to stock lengths of wire, crimp lugs and tools.

Circle (500) on Fast Fact Card

Antennas features springless option

The **Antenna Specialists** division of Allen Telecom has added a springless option to its Mosaic LMR vehicular antennas. The springless option is for applications in less rugged operating environments where the durable elastomer Dura-flex spring found in the existing Mosaic line is not necessary. The new springless Mosaic is available in both conversion and component forms for either VHF (3dB gain) or UHF (3dB and 5dB gain) frequencies. Users may choose rooftop, magnet, snap-in and thick-roof mounting options to install with their conversion antenna.

Circle (501) on Fast Fact Card

Software offers new features

RadioSoft Comstudy 2.0 incorporates new features to the existing Comstudy Pro 1.5 program. Some new features include: TIA-TSB 88 frequency coordination compliance and area reliability analysis and mapping for any propagation model. The program also includes a transmitter matrix library import/export feature and individual station matrix editing and recalculation. The program offers increased accuracy, a 32-bit operation for Windows 95/98/NT and 256-color palette for contour and coverage mapping.

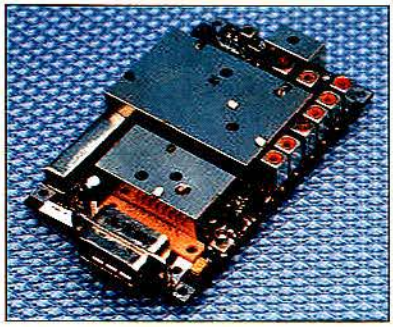
Circle (402) on Fast Fact Card

Software serves small communities

The CAD Assist 2.0 from **Global Dispatch Technology** is an emergency dispatch system that delivers the capabilities of custom-designed CAD systems in an affordable, standardized software package. Designed for operations serving communities less than 250,000 residents, the software maintains the benefits of the original CAD Assist—integrated hassle-free mapping, rapid installation, ease of use, upgradeability, user-configurability and affordability—while delivering an array of new benefits. Unlike traditional CAD systems, CAD Assist 2.0 is based on the standard Windows operating system and is Year 2000-compliant. The user-configurable product has a familiar mouse-driven interface and can be learned in hours.

Circle (403) on Fast Fact Card

Transceivers feature wide temperature



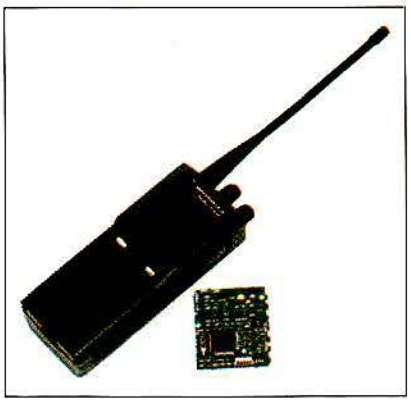
Sonik Technologies' Datalink family of high-speed analog radio transceivers accommodate transmission rates of as high as 16kbps with GMSK two-level codes and 19.2kbps with four-level codes. Coupled with a 2ms transmit-to-receive turnaround time and rugged construction, these units are suitable for TDMA, AVL and other mobile data applications. The transmitters are fully synthesized, and the current models cover the 136MHz–174MHz frequency range in 25kHz, 12.5kHz, 10kHz or 6.25kHz increments. These units feature a wide temperature range of −40° to 70°, a low standby current of only 100µA and a receive consumption of only 25mA. Output power is digitally adjustable from 1W to 4W. These units meet applicable FCC and ETSI specification requirements. The transceivers are fully MIL-SPEC rated for shock and vibration. The on-board CPU monitors temperature and compensates temperature sensitive circuits over the complete temperature range.

Circle (404) on Fast Fact Card

Chargers condition NiCD, NiMH batteries

Advanced Charger Technology's Personal Activator TBC-21M and six-bay Activator VI TBC-61M conditioning chargers are for NiCd and NiMH batteries. The chargers are designed for two-way radios and integrated digital wireless systems. The chargers condition while they charge, eliminate memory effect, triple battery life and accelerate charging times. The multichemistry chargers can fully charge a NiCd (1,000mAh battery) to full capacity in 30 minutes and a NiMH battery in one hour. The chargers recognize chemistries and adjust charging according to the individual NiCd or NiMH battery. The multichemistry Activators are immediately available for the L3000 and the i370/470 and i600 batteries, which are used for the Nextel Lingo, Southern Linc and Clearnet Mike systems.

Circle (405) on Fast Fact Card



Trunking option boards support Motorola radios

IDA's LTR trunking option boards for the Motorola P1225 hand-held radio and the M1225 mobile radio are available for all 1225 UHF and VHF models. The new release is in addition to the LTR conversion kits that IDA offers for Motorola models in the 400MHz, 800MHz and 900MHz bands. The LTR option board includes such features as scan, TX time-out timer, transpond, trunked or conventional operation, narrowband, wideband, CTCSS and CDCSS, block encode/decode, individual aliasing and automatic channel acquisition. As many as 16 systems and 16 groups per system are available depending on the radio model. Option boards supporting the advanced trunking protocol, LTR-Net, are under development.

Circle (406) on Fast Fact Card

Antenna features dial-turn downtilt

The **Celwave** Optimizer is a log periodic dipole antenna offering continuous adjustment of electrical downtilt with the simple turn of a dial. The antenna allows a carrier to adjust its footprint quickly for optimal coverage. The unit's electrical downtilt helps minimize co-channel interference. The antenna can also help minimize pilot pollution in CDMA systems. One Optimizer, with an electrical downtilt of 0° to 14°, operates over a frequency range of 806MHz–941MHz and has 11.5dBd gain and a 90° horizontal beamwidth. The other Optimizer, with an electrical downtilt of 2° to 8°, operates over a frequency range of 1,850MHz–1,990MHz and has 13dBd gain and a 90° horizontal beamwidth. Reliability is enhanced with Cellite technology, which eliminates cables and soldered joints, often the cause of reduced performance due to potential long-term IM issues.

Circle (407) on Fast Fact Card

End-user logging software flags reports

The Genesis Group's end-user logging software, GenWatch, is a fully Windows 95/98/NT-compliant software program designed to show Motorola trunking system operators who is talking on their systems. Each call is time- and date-stamped and logged for future reporting. Each unit can be "flagged" with one of the following indicators: emergency, problem, abuser, stolen or no problem. As a call is received, the program beeps or plays a verbal message of the user's choice to let him know when a "flagged" unit is talking. Additionally, when an emergency call is placed, the program sounds an alarm signal that turns off only after acknowledgment.

Circle (408) on Fast Fact Card

SSAC produces new edition of catalog

SSAC has released the fourth edition of its *In-Stock Controls Catalog*. It features time-delay relays, encapsulated timing modules, universal timers, three-phase voltage monitors, current sensors and liquid level controls. An index and a product selection guide streamline the product-selection process. Pages contain the specifications to select any in-stock part number listed. OEM prices and a list of sales representatives and stocking distributors are also included.

Circle (452) on Fast Fact Card

BCP's Web site features high-speed fiber optics

Broadband Communications Products has renovated its Web site at *www.bcpinc.com*. The revision includes enhanced navigation and searching capabilities. The site features fiber-optic products such as SONET/SDH fiber optic assemblies for telecom applications at 2.5Gbps and 10Gbps rates or Gigabit Ethernet distance extenders. The site also contains information about BCP's wide bandwidth fiber-optic antenna remoting systems and antenna microcell remoting links.

Circle (453) on Fast Fact Card

Reference gives satellite communications technology background

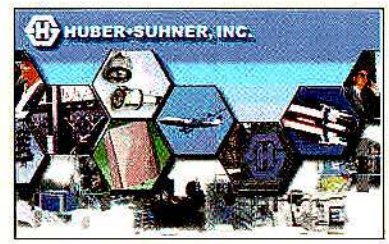
The book, *Mobile Satellite Communications*, from **Artech House**, helps communications engineers and managers develop an understanding of the fundamental background and key technologies associated with mobile satellite communications and radiodetermination systems. It includes a comprehensive overview of mobile communications and a discussion of satellite orbits, including geostationary and non-geostationary Earth-orbiting satellite communication systems.

Circle (454) on Fast Fact Card

Web site features user-friendly navigation

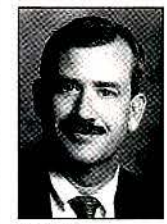
Huber+Suhner is established as a global source for RF connectors and cables, lightning protectors, antennas, components and subsystem solutions. The Web site at *www.hubersuhner.com* includes links to products, the wireless division, employment opportunities and materials technology.

Circle (451) on Fast Fact Card



people


McGee


Haley


Tennihan


Comer

Changes at CommSite International, Vienna, VA:

Wesley McGee assumes the role of chairman of the board of CommSite International. He founded CommSite in 1991. **Timothy P. Haley,** with senior operating experience at Nextel, McCaw Cellular, Metromedia/Southwestern Bell and Motorola, becomes president of CommSite.

Changes at David Clark, Worcester, MA:

Barry Tennihan, southeast regional sales manager for David Clark, advances to sales manager. **James Comer** leaves Norton Company as manager of market planning to join David Clark as international sales manager.

Laura Leigh Smith joins the Industrial Telecommunications Association, Arlington, VA, as executive director, Government Relations after serving as deputy division chief (legal) in the Public Safety and Private Wireless Division of the FCC's Wireless Telecommunications Bureau. She replaces **John Kneuer** who joins the Verner, Lipfert, Bernhard, McPherson and Hand law firm to practice private wireless law.

Robert C. Gunther, president of High Point Tower Technology, Oldsmar, FL, receives the Personal Communications Industry Association's Distinguished Corporate Citizen Award for High Point's pro bono work and leadership role in the establishment of a Severe Weather Warning Systems for Venice, FL, a community prone to hurricanes.

Richard M. Harden leaves Powertel, Atlanta, as director of network operations to join Airadigm Communications, Appleton, WI, as vice president of operations.

Chris Simpson departs Qualcomm, San Diego, as senior vice president to join Harris' RF Communications division as vice president of sales, marketing and international operations.

Dave McCurdy, former state representative, becomes president of the Electronic Industries Alliance, succeeding **Peter F. McCloskey**, who retires after 21 years as president. McCurdy was most recently chairman of the McCurdy Group L.L.C.

Changes at DSP Communications, Cupertino, CA:

Davidi Gilo, founder of DSP Communications, becomes active chairman of the board. **David Aber,** vice president of finance, advances to chief financial officer. **Nathan Hod** resigns as chairman to pursue personal interests. **Gerald Dogon,** the former chief financial officer, continues to serve as a member of the board.

Changes at Hutton Communications, Carrollton, TX:

Roger Locke, sales manager for the power systems group, advances to vice president of power systems. **Diane Barton**, assistant controller, becomes controller. **Jeff Hall** departs Centurion International, Lincoln, NE, as sales manager to join Hutton as business development manager for the radio communications product lines.

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RF ENGINEER/TECHNICIAN

Industrial Communications is one of New England's largest and most diverse tower construction companies, and # 1 Motorola dealership. Explosive growth has created the following outstanding opportunity:

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Qualifications include solid RF engineering and site development experience, using trunked Motorola 800/900 MHz systems, and strong hands on RF technical skills. Previous supervisory and training experience, as well as effective verbal/written communication skills required, BSEE preferred.

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Industrial Communications

EOE

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The County of San Mateo is seeking an experienced 2-way/microwave radio technician to maintain and repair public safety communications systems and equipment, including: base station, repeater, radio console, mobile & portable radio, analog & digital microwave, multiplexer, alarm, sound system, and video. Requires a comprehensive understanding of 2-way or microwave radio systems, at both the system and component levels.

2 years experience maintaining 2-way or microwave radio systems, valid CA driver's license, fingerprint and background check required. An FCC license or equivalent is highly desirable. Monthly salary range $4528 - $5659. Mail or FAX resume to:

County of San Mateo
Steve Dupre
501 Winslow St., RWC, CA 94063
FAX (650) 599-1121

COUNTY OF SAN MATEO

Missouri Department of Conservation

ELECTRONICS TECHNICIAN I

The Missouri Department of Conservation is seeking candidates for two Electronics Technician positions; one located in Cape Girardeau and one in the St. Louis area. Requires high school education or G.E.D. and three years experience in repair and maintenance of electronic equipment, including two-way radio communications systems, office telephone systems and data communications networks. An electronics technical certification is desirable. Salary can range from $27,924 - $49,824. For an application, call 573/751-4115.

Missouri Department of Conservation
Human Resources Section
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LTK

COMMUNICATIONS ENGINEER

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The minimum requirements for this position are a BSEE degree with 5 years of experience in the application of current communications technologies. Excellent written and oral communications skills are essential. A PE or EIT is desirable but not required.

LTK is an Equal Opportunity Employer, offering competitive compensation and benefits packages. Qualified individuals are encouraged to submit details to: *LTK Engineering Services, Attention: Human Resources Administrator, Two Valley Square, Suite 300, Blue Bell, PA 19422, Phone (215) 542-0700, Fax (215) 542-7676.*

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Send resume to:

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COMMUNICATIONS MAINTENANCE INC.
5601 Progress Road
Indianapolis, IN 46241
Attn: Personnel Dept.

COMMUNICATIONS TECHNICIAN

One of Motorola's largest independently owned service organizations is seeking motivated individuals to service and install communications products and systems. Two years experience and Naber or FCC certified preferred. Opportunities available in several locations throughout the Southeast. Top pay, benefits and 401K plan. Please send resume to:

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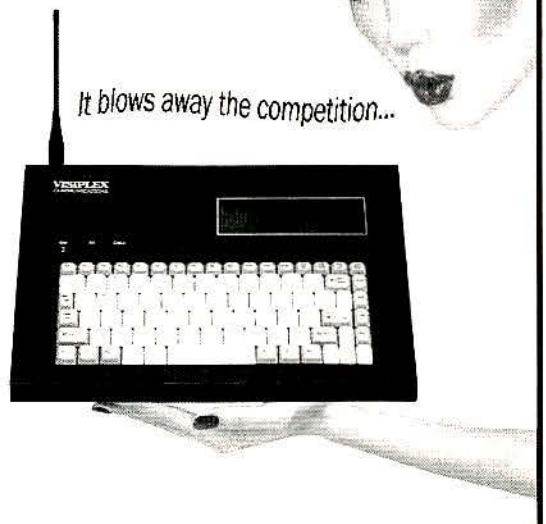

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20-MSF 5000 C74CLB 7106 UHF 110W Single/Multi user		Programmed
Special	From	$2500
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3-Micor 75W UHF Repeater		Call
1-Micor 250W UHF Repeater		Call
20-GE 900 MHz-PRC-8/9 45W Repeaters & Digital Paging Station		Call
10-900 MHz Paging Tx Mot, GE, Granger	From	$895
20-Mastr II-E 75W UHF Mobile Repeaters w/ Duplexer	From	$295
10-MICOR 800 MHz Repeaters 125W	From	$1000
50-Micor Base/Repeaters 100-375 Watt Low or VHF	From	$795
1-MSR 2000 Base/Paging TX C74GRB & C73KSB Rptr	From	$1595
20-Mastr II Base/Repeaters 60-250 Watt All Bands	From	$1495
20-Mitrek Base 100 Watt All Bands		Call
25-Aerotron Pioneer 1000 VHF Repeaters ACSB 25W		Call

Mobiles 25-50 MHz

200-Mitrek 30-39 MHz 100 Watt	Sale From	$150
300-Mitrek 39-50 MHz 60 Watt	From	$50
10-Syntor X 30-50 MHz 100 Watt	From	$495
20-Delta 36-42/42-50 MHz 100 Watt	From	$100
200 Mast II 30-50 MHz 60-100 Watt	From	$50
10-Midland 70-056B 100 Watt R/M, 36-42 MHz		$195
50-Ranger 100 Watt 32 Channel	From	$295

Mobiles 150-175 MHz

10-Mitrek 45-80 Watt 4 Ch.	From	$50
6-Midland 70-480 B R/M	From	$100
50-Syntor X 110 Watt 32 Ch	From	$200
30-Micor 45-100 Watt 4 Ch	From	$50
20-Mastr II 60-100 Watt 8 Ch	From	$50
20-Delta S 100 Watt	From	$100
50-PAC-RT 1.5 Watt Mobile Repeater	From	$100
200-Aerotron Pioneer 2000 ACSB 25W		Call

UHF Mobiles 450-470 MHz

30-Syntor X 9000 T74KEJ 110 Watt	Sale	$695
10-Spectra T84FWA7HA9AK 110Watt X9000	From	$795
4-Ranger 50Watt	From	$200
8-Delta SX 100 Watt	From	$300
20-Syntor X T34VBJ 32 Ch 110W	From	$100
20-Systems 9000 PAC-RT 4KEA300GA	From	$495
50-Mastr II 45-100 Watt Repeater Builders	From	$100
15-Mot PAC-RT Mobile Repeaters	From	$200
30-Mitrek T44JJA 50 Watt	From	$100

800 MHz Mobiles

20-Syntor X 9000, 35 Watt	From	$100
5-Spectra T45KGA55JC9AK 1&2 SmartNet w/ VRS & Siren		Call
8-Spectra D45KMA7JA5AK	Sale	$100
50-Maxtrac 800T 15-35 Watt B-1-B-7	From	$150
20-Spectra 900	Sale From	$295
20-EX II 35 Watt W/M II PA	From	$100

Misc Items

30-SpectraTac Voter Rec/Comparators		Call
40-Centracom II Control Eq. Consoles B/M, CEB, Panels, Cabinets		Call
6-Centracom I Consoles & Lots of Parts		Call
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Circle (79) on Fast Fact Card

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USED EQUIPMENT FOR SALE

300	Motorola 800 MHz GTX mobile model M11UGD6CB1
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71	Motorola 800 MHz Spectra mobile model D45KGA5JB5K
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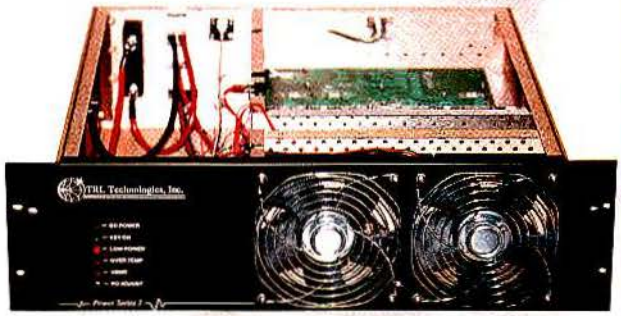

Typical High Power Unit
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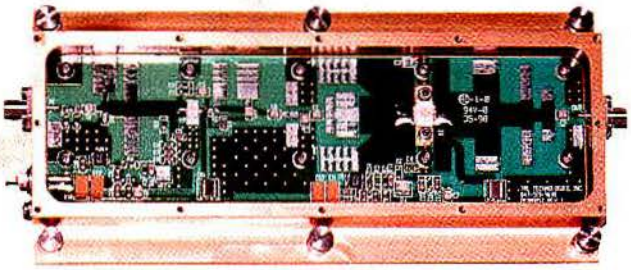
- Power levels: Class AB: 150 to 500 Watts
- Size: 19" x 5.20" x 16.5"

Typical Bi-Directional Amplifiers
- Cellular/DCS/PCS/Trunking
- Power levels: 10 to 100 Watts
- Size: 20" x 16" x 8"



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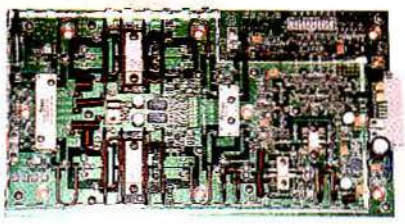

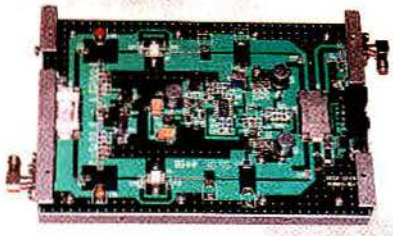

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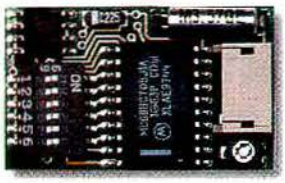

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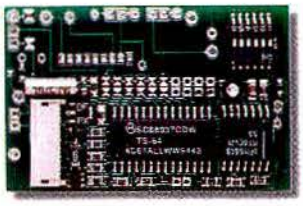

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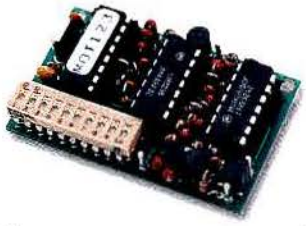

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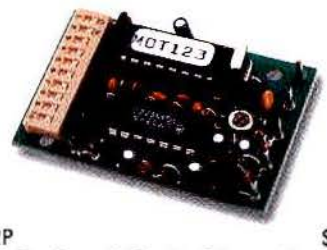

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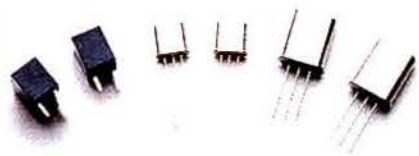

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